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USSR Report

SPACE

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MANNED MISSION HIGHLIGHTS

LAUNCH OF 'SOYUZ T-11'

Moscow PRAVDA in Russian 4 Apr 84 p 1

[TASS Report]

[Text] A spaceship, "Soyuz T-11", was launched from the Soviet Union on April 3, 1984, at 5:09 p.m., Moscow time.

This Soviet spaceship is piloted by an international crew: Yuriy Malyshev, Pilot-Cosmonaut of the USSR, Hero of the Soviet Union and the ship's commander; Gennadiy Strekalov, Pilot-Cosmonaut of the USSR, Hero of the Soviet Union and the flight engineer; and cosmonaut-researcher Rakesh Sharma, a citizen of the Republic of India.

The flight program calls for docking the "Soyuz T-11" spaceship with the orbiting complex "Salyut-7"--"Soyuz T-10" and performing joint research and experiments with cosmonauts Kizim, Solov'yev and At'kov, who have been working in near-Earth orbit since February 8, 1984.

The flight of the Soviet-Indian crew is being made in accordance with an agreement between the governments of the Union of Soviet Socialist Republics and the Republic of India.

The "Soyuz T-11" spaceship's onboard systems are functioning normally. Cosmonauts Malyshev, Strekalov and Sharma are feeling well.

The crew has begun carrying out its flight program.

FTD/SNAP

CSO: 1866/148

BIOGRAPHIC DATA ON 'SOYUZ T-11' COSMONAUTS MALYSHEV, STREKALOV AND SHARMA

Moscow PRAVDA in Russian 4 Apr 84 p 1

[Text] Yuriy Vasil'yevich Malyshev, Pilot-Cosmonaut of the USSR and Hero of the Soviet Union, was born in the city of Nikolayevsk, Volgograd Oblast, on August 27, 1941.

He graduated from the Khar'kov Higher Military Aviation School for Pilots in 1963. He subsequently served in the Air Force. He has the qualifications "Military pilot, first class" and "Test pilot, third class".

Yuriy Vasil'yevich has been a member of the Communist Party of the Soviet Union since 1964.

Yu. V. Malyshev has been in the contingent of the cosmonauts since 1967.

Yuriy Vasil'yevich graduated from the Air Force Academy imeni Gagarin in 1977, as a correspondence-course student.

Yu. V. Malyshev made his first space flight in June of 1980 as commander of the spaceship "Soyuz T-2" and of the crew of a visiting expedition on the "Salyut-6" station.

* * *

Gennadiy Mikhaylovich Strekalov, Pilot-Cosmonaut of the USSR and Hero of the Soviet Union, was born in the city of Mytishchi, Moscow Oblast, on October 28, 1940.

In 1965, he graduated from the Moscow Higher Technical School imeni Bauman and began work in a design bureau. Gennadiy Mikhaylovich proved himself to be an erudite engineer with much initiative, taking part in the development and testing of spacecraft.

G. M. Strekalov has been a member of the Communist Party of the Soviet Union since 1972.

He was enrolled in the contingent of cosmonauts in 1973. Gennadiy Mikhaylovich has made two space flights. The first was made in 1980 on the spaceship

"Soyuz T-3" and the orbiting station "Salyut-6", and the second was made in April of 1983 on the spaceship "Soyuz T-8".

* * *

Rakesh Sharma, a citizen of the Republic of India, was born in the city of Patiala on January 13, 1949.

He enrolled in the National Defense Academy in 1966. After graduating from the academy, Rakesh Sharma began service in the Indian Air Force. He served in various squadrons and flew modern airplanes.

After completing courses for test-pilots, Rakesh Sharma took part in the testing of various types of airplanes.

Major Rakesh Sharma arrived for training at the Cosmonaut Training Center imeni Gagarin in 1982. He has undergone a full course of training for flights on board the "Soyuz T" spaceship and the orbiting station "Salyut".

(Photographs of Malyshev, Strekalov and Sharma are given.)

FTD/SNAP

CSO: 1866/148

'SOYUZ T-11' COSMONAUTS' TRAINING, EXPERIENCE

Moscow GUDOK in Russian 5 Apr 84 p 4

[Article by V. Kuznetsov]

[Abstract] The article provides information on the backgrounds and training of the "Soyuz T-11" spaceship's Soviet-Indian crew: cosmonauts Yuriy Malyshev, Gennadiy Strekalov and Rakesh Sharma. It is recalled that Strekalov flew on two earlier space missions, and that he and Malyshev were the backup crew for the mission on the "Soyuz-22" spaceship. Strekalov became a member of the "Soyuz T-11" crew only during the final stage of preflight training, replacing Nikolay Rukavishnikov, who had fallen ill.

Commenting on the crew's training and conditioning, the article notes that one of the measures to prepare them for weightlessness involved lying on beds tilted so that the cosmonauts' heads were lower than their feet. The program of experiments which the cosmonauts are to perform on the orbiting station "Salyut-7" was prepared by Soviet and Indian scientists. This program has three main directions: medicine, materials science, and study of natural resources of India and the adjacent waters of the Indian Ocean.

FTD/SNAP

CSO: 1866/148

'SOYUZ T-11' PREPARES FOR DOCKING WITH 'SALYUT-7'

Moscow GUDOK in Russian 5 Apr 84 p 1

[TASS Report]

[Text] Flight Control Center, April 4, as of 1100 hours Moscow time, 12 revolutions around the Earth had been completed by the spaceship "Soyuz T-11", piloted by a Soviet-Indian crew consisting of Yu. Malyshev, G. Strekalov and R. Sharma.

In accordance with the flight program, the cosmonauts have checked the air-tightness of the spaceship's compartments, and they have performed routine operations for monitoring its onboard systems. The first two-pulse maneuver for the rendezvous with the scientific research complex "Salyut-7"--"Soyuz T-10" was executed on the fourth and fifth orbits, for the purpose of forming a working orbit.

According to data of trajectory measurements, the parameters of the "Soyuz T-11" spaceship's orbit at the present time are: maximum distance from the Earth's surface--275 kilometers; minimum distance from the Earth's surface--222 kilometers; period of revolution--89.4 minutes; inclination--51.6 degrees

The flight is proceeding normally.

Cosmonauts Malyshev, Strekalov and Sharma are feeling well.

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CSO: 1866/148

'SOYUZ T-11' DOCKS WITH 'SALYUT-7'--'SOYUZ T-10' COMPLEX

Kishinev SOVETSKAYA MOLDAVIYA in Russian 6 Apr 84 p 1

[TASS Report]

[Text] Th spaceship "Soyuz T-11" docked with the orbiting complex "Salyut-7"--"Soyuz T-10" on April 4, 1984.

After carrying out standard operations for checking the seal of the docking mechanism, the crew of the "Soyuz T-11" spaceship--cosmonauts Malyshev, Strekalov and Sharma--went into the "Salyut-7" station.

An international crew consisting of six persons is working in near-Earth space on board the scientific research complex "Salyut-7"--"Soyuz T-10"--"Soyuz T-11". They are: Soviet cosmonauts Leonid Kizim, Vladimir Solov'yev, Oleg At'kov, Yuriy Malyshev and Gennadiy Strekalov, and Rakesh Sharma, cosmonaut of the Republic of India.

The program of scientific research developed jointly by scientists of the Soviet Union and India is planned to last seven days. The plans call for research on the Earth's natural resources, study of the environment, experiments in space materials science, and medical studies.

The cosmonauts are feeling well. The onboard systems of the orbiting complex "Salyut-7"--"Soyuz T-10"--"Soyuz T-11" are functioning normally.

The joint work of cosmonauts of the Soviet Union and India opens a new page in the close collaboration of our friendly countries for purposes of the peaceful exploration of space.

FTD/SNAP

CSO: 1866/148

MEDICAL STUDIES ABOARD 'SALYUT-7'

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 6 Apr 84 p 1

[TASS Report]

[Text] Flight Control Center, April 5. The working day of the Soviet-Indian crew on board the manned orbiting complex "Salyut-7"--"Soyuz T-10"--"Soyuz T-11" began at 10 a.m. and will conclude at 12 o'clock midnight, Moscow time.

A substantial place in today's program of joint work by the international crew is reserved for medical studies and experiments which will be performed by cosmonauts of the visiting expedition Yuriy Malyshev, Gennadiy Strekalov and Rakesh Sharma. The primary expedition, crew--Leonid Kizim, Vladimir Solov'yev and Oleg At'kov--will assist them and monitor scientific instruments.

An experiment called "Optokinez" was carried out during the first half of the day. Its results will be useful in assessing possible causes of vestibular disorders during the acute period of adaptation to conditions of weightlessness, and also in providing recommendations for cosmonauts in performing visual observations.

The objectives of experiments called "Profilaktika", "Yoga" and "Membrana", which are planned for the second half of the day, are to obtain data on the effectiveness of prophylactic action on the human organism during the initial stage of flight, and on features of mineral metabolism in zero gravity.

In line with the mission program, Yuriy Malyshev, Gennadiy Strekalov and Rakesh Sharma will return to Earth in the "Soyuz T-10" ship. To this end, the cosmonauts are removing individual seats from the "Soyuz T-11" and installing them in the re-entry vehicle of the "Soyuz T-10" ship.

The cosmonauts will tell about their work in near-Earth orbit during periods of television communication.

According to the crew's reports and telemetry data, the flight of the scientific research complex "Salyut-7"--"Soyuz T-10"--"Soyuz T-11" is proceeding in full accordance with the planned program.

Leonid Kizim, Vladimir Solov'yev, Oleg At'kov, Yuriy Malyshev, Gennadiy Strekalov and Rakesh Sharma are feeling well.

[A photograph of the crew on the station is given.)

FTD/SNAP

CSO: 1866/148

DETAILS OF SOVIET-INDIAN CREW'S ADAPTATION STUDIES

Moscow MEDITSINSKAYA GAZETA in Russian 6 Apr 84 p 3

[Article by V. Pishchik, correspondent]

[Abstract] The article reports in some detail on medical experiments for studying physiological and psychological reactions of the Soviet-Indian crew during its first days on the orbiting station "Salyut-7"--the period of acute adaptation to weightlessness.

An experiment called "Vektor" is aimed at improving quantitative and vector analyses of electrocardiograms, obtaining additional information on the phase structure of the cardiac cycle and on changes in the filling of the ventricles during various periods of cardiac activity, and evaluating compensatory-adaptive reactions of the circulatory system in detail, using a number of new electrocardiographic and kinetocardiographic methods. A portable vector-cardiograph was developed for these studies by India's "KHAL" firm. In an experiment called "Ballisto", the force of heart contractions and the coordination of the functioning of the heart's right and left sections are evaluated, using the method of ballistocardiography. Data from this experiment are expected to broaden knowledge about changes in the heart's hemodynamics and function which occur in conditions of zero gravity, and thus to provide a basis for improving measures for preventing adverse effects of weightlessness.

The purpose of an experiment called "Optokinez" is to study oculomotor function and features of vestibular-visual interaction. In the course of this experiment, a cosmonaut watches for the appearance of certain visual stimuli and follows their movements on the screen of a video-tape recorder. Electrooculograms, electrocardiograms and pneumograms are recorded during the experiment. Results of the experiment are to be used in analyzing possible causes of motion sickness in flight, developing preventive measures and issuing recommendations for cosmonauts' work during visual observations.

Experiments called "Opros" (interrogation) and "Yoga" are also described. The latter was prepared by Indian specialists for performance by cosmonaut Rakesh Sharma. It is intended for studying changes in the biomechanics of motion and impairments of coordination in space. This experiment calls for recording certain parameters of the motor activity of groups of muscles during the performance of selected sets of exercise in static conditions of

activity. The "Opros" experiment employs a special questionnaire for the evaluation of effects of space flight on the crew's psychological state. The character of interactions between crew members is studied on the basis of the cosmonauts' responses to this questionnaire.

FTD/SNAP

CSO: 1866/148

MEDICAL AND GEOPHYSICAL STUDIES ON 'SALYUT-7'

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 7 Apr 84 p 1

[TASS Report]

[Text] Flight Control Center April 6. The international crew consisting of Leonid Kizim, Vladimir Solov'yev, Oleg At'kov, Yuriy Malyshev, Gennadiy Strekalov and Rakesh Sharma, a citizen of India, is working for the second day on board the orbiting complex "Salyut-7"--"Soyuz T-10"--"Soyuz T-11".

Today's schedule calls for medical and geophysical studies, motion-picture photography of joint work, and a televised report.

In the course of medical examinations performed in line with the experiments called "Vektor" and Ballisto-3", the condition of the cosmonauts' cardiovascular systems is being determined by the methods of examining the bioelectric activity of the heart and recording microtranspositions of the body which are conditioned by heart activity.

For purposes of further studying the effects of weightlessness on the osteomuscular system and improving means of prevention, cosmonaut-researcher Rakesh Sharma is doing excerises of the 'yoga' system every day. In the course of this experiment, motor and electrical activity of muscles is being evaluated periodically using recording instruments called "Miokomp" and "Briz".

The first series of geophysical studies has been completed within the framework of the experiment called "Terra". As the orbiting complex passed over the territory of India, the crew of the visiting expedition conducted visual observations and photography of the Nicobar and Lacadive islands, ring structures on the Indostani peninsula, and ice and snow cover of the Himalayas. Waters of the Indian Ocean also were studied for the purpose of determining its biological productivity in separate regions.

Onboard systems and scientific apparatus of the orbiting complex are functioning normally.

The condition of the health of cosmonauts Kizim, Solov'yev, At'kov, Malyshev, Strekalov and Sharma is good, and they are feeling well. The international crew is working harmoniously.

FTD/SNAP

CSO: 1866/148

FEATURES OF 'ISPARITEL'-M' APPARATUS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 13 Mar 84 p 4

[Article by G. Lomanov, special correspondent at the Flight Control Center]

[Excerpt] Candidate of Technical Sciences V. Lapchinskiy, head of a laboratory of the Institute of Electric Welding imeni Paton, communicated with the crew several times before the beginning of an experiment.

"Don't worry; we're already sure that your unit is working excellently," flight engineer V. Solov'yev reassured him.

The crew has performed the latest series of experiments with a new unit, the "Isparitel'-M". It is intended for depositing metal and polymer coatings on various substrates.

The main working tool of the "Isparitel'-M" is an electron-beam gun. It shoots a beam of electrons at a refractory crucible filled with silver, copper, gold or a copper-silver alloy. This metal begins to vaporize and the vapors settle on a metal or glass plate, forming a mirror-like coating. Actually, only the unit itself can be called an innovation here; the letter "M" in its name stands simply for 'modernized'.

"What distinguishes the modernized variant of the 'Isparitel'', and what are its capabilities?"

"During the initial experiments, we wanted to ascertain that metal can be vaporized in space. After all, up until now work with melts in orbit has been done only in airtight capsules, but we are using an open crucible. I need hardly remind you that in zero gravity it is not easy to keep even ordinary water inside a glass. An experimental check made it possible to find an optimal shape for the crucibles and working heads and to make a number of improvements in the design of the 'Isparitel''.

"A wide range of applied tasks can now be accomplished with the aid of the new unit. The 'Isparitel'-M' can already deposit coatings as thick as tenths of a millimeter; its capacity is larger and its vaporization speed is higher. But its main feature is something different: this completely automated apparatus can perform eight different kinds of work. For example, neither metals nor plastics necessarily have to be deposited on glass or a metal plate, as was formerly the case; they can also be deposited on a

polymer film. Lastly, the unit has become a multipurpose one; we can not only vaporize but also melt materials, as is done in the well-known space furnaces 'Splav' and 'Kristall'."

"You once said that the electron 'gun' could be converted into a 'pistol', with which a cosmonaut could work in space in approximately the same manner as a painter operates a hand paint-sprayer. Has this happened?"

"Yes, a series of experiments performed on board 'Salyut' stations enabled us to begin developing a versatile hand tool for space mechanics. Any metals and alloys can be cut, welded and soldered and thin-film coatings applied in open space with the aid of this tool. One variant of such a 'pistol' has already been perfected."

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COMMENTS BY DEVELOPERS OF 'ISPARITEL'-M'

Kiev PRAVDA UKRAINY in Russian 27 Mar 84 p 4

[Article by V. Petrenko]

[Excerpt] Two associates of the Institute of Electric Welding imeni Paton--V. Lapchinskiy, head of a laboratory, and A. Zagrebel'nyy, head of a group--have returned to Kiev from a business trip. In March, cosmonauts L. Kizim, V. Solov'yev and O. At'kov began technological experiments with the Paton institute's new unit "Isparitel'-M" on board the orbiting complex, and the unit's developers conducted a businesslike radio dialog with the cosmonauts from the Flight Control Center. Lapchinskiy and Zagrebel'nyy, organizers of the experiment, related: V. Lapchinskiy: "The design features of the unit now in space which distinguish it from our first unit go far beyond ordinary modernization. We have incorporated several new solutions in the 'Isparitel'-M'; its capacity and productivity have been increased, and it is able not only to vaporize various materials but also to melt them. The unit has been designed with the capability of quick replacement of assemblies of the electron-beam guns by the cosmonauts."

A. Zagrebel'nyy: "The range of substances that can be vaporized and subsequently deposited in the form of coatings has become substantially broader; among these substances are silver, gold, copper, a copper-silver alloy, a number of other metals and alloys, and nonmetallic materials such as plastics, for example. And coatings are now applied not only to metal or glass plates, but also to tape made of a polymer film that is drawn over the stream of vapors."

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ALLOY SUPERCOOLING EXPERIMENT ON 'SALYUT-7'

Moscow IZVESTIYA in Russian 11 Apr 84 p 3

[Article by B. Konovalov, correspondent at the Flight Control Center]

[Abstract] The article provides background information on the materials-science experiment called "Pereokhlazhdeniye" (supercooling) that was performed during the mission of the Soviet-Indian crew on the orbiting station "Salyut-7".

Regarding the procedure for carrying out the experiment, the following is related: "The cosmonauts installed a special unit in the Soviet technological unit 'Isparitel'. This special unit is for studying specimens of a germanium-silver alloy which were prepared at the metallurgical laboratory in Hyderabad, the home town of Rakesh Sharma. These specimens were pellets 3 millimeters in diameter, and they were suspended in the unit with the aid of a cleverly devised system on special nooses, so that they did not touch the walls of the crucible in which they were melted by the beam of an electron gun. The 'Isparitel' unit was placed in an airlock chamber, and the cooling was accomplished through the cold of outer space, in a vacuum. During the process, thermocouples mounted in the sepcimens made it possible to measure the degree of supercooling in the course of the experiment. For the silver-germanium alloy, the relationship of its structure to the degree of supercooling had already been well-studied on Earth. Scientists are hoping that in the conditions of outer space, simple heating and cooling will be sufficient for obtaining glassy metals."

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FURTHER DETAILS ON ALLOY SUPERCOOLING EXPERIMENT ON 'SALYUT-7'

Moscow TRUD in Russian 11 Apr 84 p 4

[Article by I. Melenevskiy, correspondent at the Flight Control Center]

[Abstract] The article reports on photography and medical and materials-science experiments that were being completed by the Soviet-Indian crew at the conclusion of their mission on the orbiting station "Salyut-7".

At the Flight Control Center, Candidate of Technical Sciences V. F. Lapchinskiy and Candidate of Chemical Sciences G. V. Zhukov commented on the materials-science experiment called "Pereokhlazhdeniye" (supercooling). They explained that in experiments on Earth with supercooling of a silver-germanium alloy, deep supercooling of the alloy had to be accomplished by melting one side of the alloy with a laser, while the other side was cooled with liquid helium. The product of this complex and costly process is a metal that holds up well to effects of radiation. Two examples of applications of such a product are said to be in walls of nuclear reactors, and in turbine blades of airplane engines. In the latter application, it is noted that a 100-degree increase in the temperature tolerance of turbine blades permits a 30-percent reduction in fuel consumption. The experiment was intended to demonstrate that the supercooling process can be accomplished more easily and less expensively in zero gravity. The experiment is said to represent an initial step toward the industrial production of superdurable materials capable of withstanding radiation and chemical stresses.

Indian specialists are credited with preparing the alloy specimens for the experiment. An original method of heating them was proposed by scientists of the laboratory of experimental metallurgy in the city of Hyperabad. The "Isparitel'-M" unit in which the experiment was conducted was developed by the Ukrainian Academy of Sciences' institutes of electric welding imeni Paton.

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PHOTOGRAPHY, MEDICAL AND MATERIALS EXPERIMENTS ON 'SALYUT-7'

Moscow KOMOSOMOL'SKAYA PRAVDA in Russian 8 Apr 84 p 1

[TASS Report]

[Text] Flight Control Center, April 7. Cosmonauts Leonid Kizim, Vladimir Solov'yev, Oleg At'kov, Yuriy Malyshev, Gennadiy Strekalov and Rakesh Sharma are successfully continuing their joint work on board the scientific station "Salyut-7".

Another cycle of the "Terra" geophysical studies was performed during the first half of the day. In line with requests from specialists in the fields of geology, soil science, agriculture and water resources, the cosmonauts conducted visual observations and photography of the waters of the Bay of Bengal, the west coast and desert zone of India, the Ganges River valley and the Himalayas. Photography was performed using hand-held cameras and the stationary cameras MKF-6M and KATE-140.

The medical portion of the mission's scientific program is represented today by the experiments "Profilaktika", "Yoga", "Anketa" and "Opros", in which studies of effects of space-flight factors on the human organism are continuing, as well as the perfecting of methods and equipment for preventing adverse effects of weightlessness.

In line with the space materials-science program, the crew of the visiting expedition began a series of experiments called "Pereokhlazhdeniye" (supercooling) in the "Isparitel'" unit today. The purpose of these experiments is to study the phenomenon of supercooling in the solidification of molten metals and to investigate possibilities for obtaining special forms of metallic materials, so-called 'glassy alloys,' in conditions of microgravitation.

For the purpose of performing these experiments in the "Isparitel'", an auxiliary unit was built by Soviet specialists and the Indian side prepared specimens in which a silver-germanium alloy is used as a model material.

In the evening, during two periods of television communication, the crew held an inflight press conference for Soviet and foreign journalists who are covering this mission.

According to results of medical examinations, the condition of the health of cosmonauts L. Kizim, V. Solov'yev, O. At'kov, Yu. Malyshev, G. Strekalov and R. Sharma is good.

The flight of the scientific research complex "Salyut-7"--"Soyuz T-10"--"Soyuz T-11" is proceeding normally.

FTD/SNAP

CSO: 1866/148

COMMENTARY ON ADAPTATION STUDIES ON 'SALYUT-7'

Moscow IZVESTIYA in Russian 7 Apr 84 p 3

[Article by B. Konovalov, correspondent at the Flight Control Center]

[Abstract] The short article reports on medical studies that were being done during the first days of the Soviet-Indian crew's stay on the orbiting station "Salyut-7". The studies were focused on the so-called 'period of acute adaptation to weightlessness.'

In an experiment called "Profilaktika", Yuriy Malyshev and Gennadiy Strekalov were testing special cuffs of different designs, called "Pnevmatik" and "Braslet", which are intended for slowing the flow of blood from the lower half of the body, so that the rush of blood to the head is not so intensive.

In an experiment called "Yoga", cosmonaut-researcher Rakesh Sharma sought to determine whether yoga exercises may have any effect in preventing discomforts due to weightlessness. It is noted that in the preflight preparation for this experiment, he did these exercises for one hour every day for a month and a half, and he was continuing to do them on the station, strapped into position on the physical-exercise set. Marshal of Aviation Munk Radj, chief of the medical service of India's Air Force, told journalists at the Flight Control Center that specialists believe yoga exercises can help reduce functional impairments of the cardiovascular system which occur in zero gravity. The usefulness of yoga in preventing atrophy of muscles is also of interest to space medicine researchers.

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CSO: 1866/148

MEDICAL AND GEOPHYSICAL STUDIES CONTINUE ON 'SALYUT-7'

Moscow KRASNAYA ZVEZDA in Russian 10 Apr 84 p 1

[TASS Report]

[Text] Flight Control Center, April 8. The international crew consisting of Leonid Kizim, Vladimir Solov'yev, Oleg At'kov, Yuriy Malyshev, Gennadiy Strekalov and Rakesh Sharma is working for the fourth day on board the orbiting complex "Salyut-7"--"Soyuz T-10"--"Soyuz T-11".

A substantial place in today's program is reserved for medical research aimed at further study of the effects of space flight factors on the human organism. In the course of the experiments "Ballisto-3" and "Optokinez", indicators that characterize the condition of the cardiovascular system are being determined, and the interaction of the vestibular apparatus and the visual system is being studied. Results of the experiments "Profilaktika" and "Yoga" will help to develop more effective means of preventing the unpleasant effects of weightlessness.

In line with the program of the geophysical experiment "Terra", the crew conducted another series of photography of the territory of India. Today the east coast of the Indostan peninsula and the Ganges River delta were photographed.

Plans for the second half of the day call for one more experiment in space materials science, and a televised report during which the cosmonauts will tell about their work.

Flight Control Center, April 9. Cosmonauts Leonid Kizim, Vladimir Solov'yev, Oleg At'kov, Yuriy Malyshev, Gennadiy Strekalov and Rakesh Sharma are continuing joint work on board the orbiting scientific station "Salyut-7".

The crew of the visiting expedition has carried out another series of geophysical studies in the program of the "Terra" experiment. Today photography was conducted over regions of the Andaman and Nicobar islands for the purpose of finding oil- and gas-bearing areas in shallow waters; blocks of forests and forest plantations in the central part of the Indostan peninsula were examined, as was the water-resource management situation in the Ganges River basin.

In line with the program of medical research, experiments will be performed during the second half of the day for the study of the functional condition of the cosmonauts' cardiovascular systems, and for obtaining data on the effectiveness of means of preventing unpleasant effects of weightlessness on the human organism. Using a specially developed list of questions, the cosmonauts will give an evaluation of subjective sensations during the period of adaptation to space flight conditions.

Also planned for today are an experiment to evaluate the dynamics of change of the gas-atmosphere composition in the living compartments of the orbiting complex, and also a number of microbiology studies.

The flight of the scientific research complex "Salyut-7"--"Soyuz T-10"--"Soyuz T-11" is proceeding normally. All the cosmonauts are healthy, and they are working harmoniously and with good spirits.

FTD/SNAP

CSO: 1866/148

CARDIOGRAPHY AND MATERIALS EXPERIMENTS ON 'SALYUT-7'

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 10 Apr 84 p 4

[Article by G. Lomanov, special correspondent at the Flight Control Center]

[Abstract] The article provides information on cardiography and materials-science experiments which were being performed on the orbiting station "Salyut-7" during the mission of the Soviet-Indian crew.

Electrocardiograms were being recorded both during rest and during physical exertion on the exercycle, using a portable vectorcardiograph which India's "KHAL" firm developed for the mission. This instrument not only records the heart's electrical activity on tape, it also records vibrations of the chest caused by heartbeats. Another experiment, called "Ballisto", was intended to study how the heart's functioning is affected by changes of the position of the heart in the chest which occur in conditions of weightlessness. For this purpose, movements of the body caused by the heart's activity are recorded using sensors attached to various parts of the body. Movements are recorded in three directions in this experiment, whereas in previous experiments of this kind, the movements were recorded in just one direction.

Materials-science experiments with the supercooling of melts were being performed in the "Isparitel'" unit, whose electron gun is said to offer very flexible capabilities for the rapid heating and cooling of materials. The experiments aimed at obtaining glassy alloys through the supercooling of melts. Whereas the effect usually is achieved only in thin layers on Earth, it is believed that melts with fairly large volumes can be supercooled rapidly and more deeply in zero gravity.

FTD/SNAP

CSO: 1866/148

SOVIET-INDIAN CREW PREPARES FOR RETURN TO EARTH

Moscow GUDOK in Russian 11 Apr 84 p 3

[TASS Report]

[Text] Flight Control Center, April 10. The orbital flight of Yuriy Malyshev, Gennadiy Strekalov and Rakesh Sharma, India's first cosmonaut, is nearing completion. They have been working with Leonid Kizim, Vladimir Solov'yev and Oleg At'kov on board the "Salyut-7" station since April 4. The crew of the visiting expedition is performing the final experiments of its scientific program and preparing for the return to Earth.

The cosmonauts carried out one more series of "Terra" geophysical studies during the first half of the day, as the station's flight path passed over the territory of India. The west coast and central portion of the Hindustan Peninsula were photographed with the aid of the stationary cameras MKF-6M and KATE-140.

Preparations have begun for the descent from orbit of the transport spaceship "Soyuz T-10", in which Yu. Malyshev, G. Strekalov and R. Sharma will return to Earth tomorrow. Equipment which is to be returned, exposed motion-picture and photographic films, specimens of alloys obtained in the course of technological experiments, and other materials containing information on research that was carried out are being stowed in this spaceship's reentry vehicle.

The crew will also check the functioning of the spaceship's systems which ensure its descent from orbit.

FTD/SNAP

CSO: 1866/148

INNOVATIONS IN COSMONAUT MEDICAL MONITORING, PHYSICAL CONDITIONING

Moscow MEDITSINSKAYA GAZETA in Russian 11 Apr 84 p 3

[Article by V. Pishchik, correspondent]

[Abstract] On the occasion of Cosmonautics Day, the article records a conversation with academician Yevgeniy Ivanovich Chazov, director of the USSR Academy of Medical Sciences' All-Union Cardiology Research Center, and academician Oleg Georgiyevich Gazenko, director of the USSR Public Health Ministry's Institute of Medical-Biological Problems. The conversation was held at the medical-biological Institute's Medical Information Gathering and Processing Center, where medical monitoring information from the manned orbiting station "Salyut-7" is received regularly. Chazov and Gazenko commented on the status of medical-biological research aimed at heightening the safety and fitness of cosmonauts on prolonged space missions, and on results of the first two months of work of cosmonuats Leonid Kizim, Vladimir Solov'yev and Oleg At'kov on board "Salyut-7".

Gazenko devoted particular attention to the cosmonauts' metabolism studies and to the new physical-conditioning regime they are using. It is noted that the new set of physical exercises consumes less time than exercises performed during previous prolonged missions, but is more intensive and strenuous. Cosmonaut-physician At'kov is instrumental in directing the evaluation of the effectiveness of the new regime. Gazenko mentioned that changes have also been made in conditioning and examination routines in which effects of negative pressure are produced on the lower half of the body with the aid of the special suit "Chibis". During the current mission, studies have been conducted in this suit at an atmosphere rarefaction level of 45 millimeters of mercury, for the first time in space. The mission is also the first one in which blood samples are being taken from veins as well as fingers in monitoring of the cosmonauts' hormones, water-salt metabolism and blood.

Chazov hailed the potential of ultrasonic echocardiography for evaluating the activity of the cardiovascular system. Its reserve capabilities can also be judged by this method, it is noted. This in turn aids the prescribing of physical exertion in the correct measured amounts at various stages of a mission, as well as the efficient organization of complex operations. Chazov also said that At'kov psychological training will enable him to study certain psychological problems which occur in small groups on prolonged missions.

FTD/SNAP

BALLISTOCARDIOGRAPHY AND SALT-LOSS STUDIES ON 'SALYUT-7'

Moscow MEDITSINSKAYA GAZETA in Russian 13 Apr 84 p 3

[Article by Yu. Faybishenko]

[Abstract] The article discusses methods and objectives of medical-biological experiments which were performed during the Soviet-Indian crew's mission on the orbiting station "Salyut-7".

The experiment called "Ballisto" employed the method of spatial ballistocardiography, by which extremely slight movements of the body are recorded from three mutually perpendicular axes. Ballistocardiograms of members of the crew were recorded using a piezoelectric accelerometer that was attached to three different parts of the body in succession. Three-dimensional pictures of the distribution of forces of heart contraction were obtained by this method. They are expected to permit more profound study of processes of the conversion of vibrational energy and expand possibilities for studying the contractile function of the heart and its right and left ventricles. New data on the magnitude and spatial distribution of the energy of heart contractions and on effects of weightlessness on this distribution reportedly have been obtained as a result of this experiment.

An experiment called "Membrana" was conducted for the purpose of studying the mechanism of salt loss in conditions of weightlessness, as well as the effectiveness of biochemical methods for retarding this process. Cosmonaut Oleg At'kov performed this experiment with the aid of a special case containing 30 airtight ampules filled with biocomponents, as well as accessories for taking blood from fingers and injecting it into the ampules. At the beginning and end of the Soviet-Indian crew's work, At'kov took blood samples from flight engineer Gennadiy Strekalov and transferred them to certain ampules. Observations from the experiment were recorded in a flight log, and the ampules were delivered in their case to Earth for further analysis.

It is mentioned in conclusion that new projects of joint Soviet-Indian space research are planned in line with the "Intercosmos" program. These plans call in particular for launching a fourth Indian satellite for remote study of the Earth, in 1986.

FTD/SNAP

CSO: 1866/148

'SOYUZ T-11' CHANGES DOCKING POSITION ON 'SALYUT-7'

Moscow KRASNAYA ZVEZDA in Russian 14 Apr 84 p 3

[TASS Report]

[Text] Flight Control Center, April 13. Soviet cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov have been working in near-Earth orbit for 65 days.

In accordance with the flight program, today they changed the docking position of the "Soyuz T-11" ship from the equipment compartment of the station to its transfer compartment. The rearranging of the orbiting complex was carried out for the purpose of facilitating transport operations for the supplying of the "Salyut-7" station with various cargo items necessary for the crew's life-support and work.

Before the operation, the cosmonauts checked the functioning of the complex's systems, went into the "Soyuz T-11" ship and closed the transfer hatches. The ship separated from the "Salyut-7" station at 2:27 p.m., Moscow time.

Systems for mutual search and rendezvousing of both spacecraft were activated at the calculated time. The station made a turn, and then the ship approached and docked with it on the side of its transfer compartment.

After checking the seal of the docking mechanism, the cosmonauts opened the hatches and went inside the station.

At all stages of the maneuver, the onboard systems of the "Salyut-7" station and the "Soyuz T-11" spaceship functioned normally. The crew worked confidently and precisely.

The work in near-Earth orbit is continuing. Cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov are healthy and are feeling well.

FTD/SNAP

CSO: 1866/148

'PROGRESS-20' CARGO SHIP LAUNCHED

Moscow IZVESTIYA in Russian 16 Apr 84 p 1

[TASS Report]

[Text] In accordance with the program of ensuring the further functioning of the orbiting scientific station "Salyut-7", the automatic cargo ship "Progress-20" was launched from the Soviet Union on April 15, 1984, at 12:13 p.m., Moscow time.

The purpose of the ship's launching is to deliver expendable supplies and various cargo items to the orbiting station.

The "Progress-20" ship was placed into an orbit with the parameters: maximum distance from the Earth's surface--277 kilometers; minimum distance from the Earth's surface--192 kilometers; period of revolution--88.9 minutes; inclination--51.6 degrees.

According to telemetry data, the onboard systems of the automatic cargo ship are functioning normally.

FTD/SNAP

CSO: 1866/148

'PROGRESS-20' DOCKS WITH 'SALYUT-7'

Moscow SOTSIALISTICHESKAYA INDUSTRIYA 18 Apr 84 p 1

[TASS Report]

[Text] The cargo ship "Progress-20" docked automatically with the manned orbiting complex "Salyut-7"--"Soyuz T-11" on April 17, 1984, at 1:22 p.m., Moscow time.

The mutual search, rendezvousing, approach and docking of the spacecraft were executed with the aid of onboard automation equipment. These processes were monitored by the Flight Control Center and the crew of the orbiting complex--cosmonauts Kizim, Solov'yev and At'kov. The cargo ship was docked to the station on the side of its equipment compartment.

The "Progress-20" ship delivered into orbit fuel for the combined engine assembly of the station, as well as equipment, apparatus and materials for scientific research and for the crew's life support, and also mail.

According to the crew's reports and telemetry data, the onboard systems of the scientific research complex "Salyut-7"--"Soyuz T-11"--"Progress-20" are functioning normally.

FTD/SNAP

CSO: 1866/148

'PROGRESS-20' BOOSTS ORBIT OF 'SALYUT-7'

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 21 Apr 84 p 3

[TASS Report]

[Text] Flight Control Center, April 20. The space mission of Leonid Kizim, Vladimir Solov'yev and Oleg At'kov is continuing.

In past days the crew of the orbiting complex has been busy unloading the "Progress-20" transport ship and arranging and setting up the equipment that it delivered. The cosmonauts moved containers of products, units of the life-support system and means of personal hygiene inside the station, and they installed a new block of chemical batteries.

A correction of the orbit of the scientific research complex was executed with the aid of the cargo ship's engine. Its orbit parameters are now: maximum distance from the Earth's surface--332 kilometers; minimum distance from the Earth's surface--301 kilometers; period of revolution--90.6 minutes; orbit inclination--51.6 degrees.

One day last week was reserved for a medical examination of the crew.

FTD/SNAP

CSO: 1866/148

COSMONAUTS KIZIM AND SOLOV'YEV PERFORM EVA

Moscow PRAVDA in Russian 24 Apr 84 p 1

[TASS Report]

[Text] Flight Control Center, April 23. The crew of the orbiting complex "Salyut-7"--"Soyuz T-11"--"Progress-20" is continuing to carry out its planned flight program.

Today, cosmonauts Leonid Kizim and Vladimir Solov'yev made an egress into open space and performed operations in preparation for work outside the station which is planned in the future.

The station's exit hatch was opened at 8:31 a.m., Moscow time, and the commander and flight engineer went out into open space. They removed a special ladder, which was folded up, and containers with tools and necessary materials from the station's transfer compartment, and then took them to the place where they were to work. The cosmonauts unfolded the ladder and installed it on the outer surface of the station. The containers were fastened in the same place.

After performing this work and other preparatory operations, the cosmonauts went back inside the station. The total time spent by Leonid Kizim and Vladimir Solov'yev in open space was 4 hours and 15 minutes. During the time of the cosmonauts' egress, cosmonaut-researcher Oleg At'kov was inside the station's working compartment, monitoring the functioning of onboard systems and maintaining communications with the commander and flight engineer.

The Flight Control Center had radio conversations with all of the crewmembers while the work in open space was in progress.

The crew of the orbiting complex operated precisely and in strict accordance with the planned schedule during the performance of all of their work in open space and inside the station.

FTD/SNAP

CSO: 1866/148

TASS REPORTS EVA FOR FUEL LINE REPAIR

Riga SOVETSKAYA LATVIYA in Russian 28 Apr 84 p 1

[TASS Report]

[Text] Flight Control Center, April 26. In line with the mission program, cosmonauts Leonid Kizim and Vladimir Solov'yev have made a second egress into open space.

Today at 6:40 a.m., Moscow time, cosmonauts Kizim and Solov'yev opened an outer hatch of the station, went out onto its outer surface and made their way to the place of work on the equipment compartment.

Using special tools, the cosmonauts opened up a protective cover at the place where a shut-off part of the reserve line of the combined engine assembly is located and installed a valve. They pressurized this line and checked its tightness. After completing the planned procedures, the cosmonauts returned to the entry compartment and went inside the station. The total time that Kizim andSolov'yev were outside the station in open space for 5 hours.

Cosmonaut-researcher Oleg At'kov, who remained inside the station during the extra-vehicular activity of the commander and the flight engineer, monitored the functioning of onboard systems and checked on how cosmonauts Kizim and Solov'yev were feeling. The health of comrades Kizim, Solov'yev and At'kov is good.

In carrying out the complex and exerting work in open space, the crew of the orbiting complex "Salyut-7"--"Soyuz T-11"--"Progress-20" worked smoothly and confidently, demonstrating high professional skill.

Further work in open space is planned.

FTD/SNAP

CSO: 1866/148

DETAILS OF COSMONAUTS' EVA ON 26 APRIL

Moscow GUDOK in Russian 27 Apr 84 p 3

[Article by B. Kuznetsov]

[Abstract] The article reports some of the details of the work of cosmonauts Leonid Kizim and Vladimir Solov'yev outside the orbiting station "Salyut-7" on April 26.

It is explained that the work was scheduled for the early morning hours, Moscow time, so that it could be monitored during daylight flyovers of Soviet territory by specialists at the Flight Control Center. This scheduling, combined with tracking by ships located in the Atlantic and Pacific oceans, extended the period of radio visibility from 20 to 50 minutes. The cosmonauts moved along a handrail a total of 15 meters to the station's equipment compartment, where they had installed a ladder and a pack of containers with tools three days earlier. It is noted that their work was monitored and directed at the Flight Control Center by Valeriy Ryumin, who on an earlier mission had made a spacewalk to the same part of the "Salyut-6" station. At the place of work, Kizim anchored himself on the ladder that had been installed earlier. Solov'yev anchored himself on a special extension that had been built for this purpose into the "Progress-20" cargo ship, which is docked to the station's equipment compartment. This extension was deployed and locked into place on commands from Earth.

Concerning the goal of the EVA, it is said that the cosmonauts had to check the tightness of one of the reserve lines of the engine. They opened a recess to gain access to control fillers. Solov'yev had to cut through lining using a cutter that resembled a large butter knife. The time of the EVA was 5 hours.

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CSO: 1866/148

FURTHER DETAILS OF EVA TO REPAIR FUEL LINE ON 'SALYUT-7'

Mosocw KOMSOMOL'SKAYA PRAVDA in Russian 27 Apr 84 p 4

[Article by A. Ivakhnov, correspondent at the Flight Control Center]

[Abstract] The article gives background information and excerpts of communications between the "Salyut-7" cosmonauts and the Flight Control Center during the extravehicular activity to repair a fuel line on the station.

It is noted that the kit for the repair work included 25 specially made tools, which weighed a total of 40 kilograms. On the first EVA, cosmonauts Kizim an Solov'yev had to drive anchor pins into the plastic exterior of the station's equipment compartment for the installation of the ladder used in the repair work. On the second EVA, they had to cut a window in the plastic to gain access to a control filler of an oxidizer line. They used a piercing tool to make a hole for a special knife, with which they cut out a section large enough to work on the filler. The filler had a plug fastened with a nut which was covered with an epoxy putty. The removal of this nut presented considerable difficulty, according to the account of the communications. After spending two hours on it, they succeeded in removing it with a reducer wrench with a system for increased force on the nut.

With the filler open, the cosmonauts replaced a valve in the line. Then on command of cosmonaut At'kov inside the station, the line was pressurized with nitrogen from tanks on the "Progress-20" cargo ship. After this they reported they still weren't tired and asked mission control for extra time, which was granted. The total time of the EVA was just short of five hours, instead of the planned four hours and five minutes.

FTD/SNAP

CSO: 1866/148

TASS REPORTS THIRD EVA OF 'SALYUT-7' COSMONAUTS

Moscow MOSKOVSKAYA PRAVDA in Russian 30 Apr 84 p 3

[TASS Report]

[Text] Flight Control Center, April 29. In line with the flight program of the orbiting complex "Salyut-7"--"Soyuz T-11"--"Progress-20", cosmonauts Leonid Kizim and Vladimir Solov'yev have made their third egress into open space. At 5:35 a.m., Moscow time, the crew commander and the flight engineer opened a hatch of the station and went out onto its outer surface. They moved along the station to its equipment compartment and continued work on a shut-off part of the reserve line of the combined engine assembly.

Using special tools, the cosmonauts did necessary preparatory work, installed an additional line, and checked its tightness.

A heat-shield coating was reconditioned for the purpose of ensuring the orbiting station's heat conditions. The cosmonauts then placed the tools in a container, returned to the entry compartment and went inside the station.

During the time of the crew commander's and flight engineer's work in open space, cosmonaut-researcher Oleg At'kov monitored the functioning of onboard systems and kept the condition of Kizim's and Solov'yev's health under observation.

During this egress, Leonid Kizim and Vladimir Solov'yev spent 2 hours and 45 minutes in outer space.

The condition of the cosmonaut's health is good.

Work by the crew in open space will be continued during the further flight of the orbiting complex.

FTD/SNAP

CSO: 1866/148

COMMENTARY ON THIRD EVA OF 'SALYUT-7' COSMONAUTS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 30 Apr 84 p 4

[Article by G. Lomanov, correspondent at the Flight Control Center]

[Abstract] The article provides commentary on the extravehicular activity carried out by cosmonauts Leonid Kizim and Vladimir Solov'yev on the "Salyut-7" orbiting station on April 29. Following is an excerpt from the account of the activity:

"...We have already reported that the section of the line that has become the work zone of the space installers was shut off [at an earlier time]. And if a road is closed, a bypass must be made. Vladimir Solov'yev and Leonid Kizim today connected both filler tubes with a metal bypass line... Then on commands from Earth, the cargo ship came into play. Nitrogen coming from it filled the line--if the pressure held, that would mean that everything was in order. Telemetry showed that the line was tight, meaning that the bypass pipeline installed by V. Solov'yev and L. Kizim can be used in the system of the combined engine assembly. 'An excellent job,' flight director V. Ryumin communicated to the crew. 'Now you can close the 'windows.' This was the final task: the cosmonauts placed a heat-insulating screen over the holes that they cut out last time above the filler tubes to get to the plugs. This is necessary to maintain normal temperature conditions in the equipment compartment.

FTD/SNAP

CSO: 1866/148

TASS REPORTS 'SALYUT-7' COSMONAUTS' FOURTH EVA

Moscow IZVESTIYA in Russian 5 May 84 p 2

[TASS Report]

[Text] Flight Control Center, May 4. The mission of Leonid Kizim, Vladimir Solov'yev and Oleg At'kov on board the orbiting scientific station "Salyut-7" has lasted 85 days.

The crew is completing planned operations involving the "Progress-20" transport ship. The cosmonauts have placed most of the delivered cargo items in their assigned places, and they have pumped drinking water into the station's tanks with the aid of the "Rodnik" system.

In line with the schedule of operations, Leonid Kizim and Vladimir Solov'yev made a fourth egress into open space today.

AT 3:15 a.m., Moscow time, the cosmonauts opened the outer hatch of the station and moved to the place of work on the equipment compartment.

The commander and flight engineer removed a heat-shield cover that was installed during a previous egress, and they installed a second additional line and checked its tightness. Then the cosmonauts again put the heat-shield cover into place, placed tools into a container, and returned to the station.

As on the previous egresses, cosmonaut-researcher Oleg At'kov worked inside the station.

The time that Leonid Kizim and Vladimir Solov'yev spent in open space on this egress was two hours and 45 minutes. The condition of the health of all the crew members is good.

For the first time in the practice of manned flights, cosmonauts have worked in open space during four egresses totaling 14 hours and 45 minutes over a period of 12 days, performing complex and laborious installation-and-assembly work.

Continuation of work in open space is planned in the course of the further flight of the orbiting complex.

FTD/SNAP

CSO: 1866/148

TASS REPORTS DESTRUCTIVE REENTRY OF 'PROGRESS-20'

Moscow IZVESTIYA in Russian 8 May 84 p 1

[TASS Report]

[Text] Flight Control Center, May 7. The flight of the automatic transport spaceship "Progress-20", which was placed into near-Earth orbit on April 15, 1984, has been completed.

The cargo ship docked with the "Salyut-7" station on April 17 and functioned as part of the orbiting complex until May 6. Planned work, including the unloading of the spaceship, the refueling of the station's combined engine assembly and the pumping of drinking water into tanks of the station, was fully accomplished during the joint flight. A correction of the scientific research complex's orbit was executed with the aid of the cargo ship's engine.

The transport spaceship "Progress-20" was separated from the "Salyut-7" station on May 6, at 9:46 p.m., Moscow time. On May 7, the ship was put into a descending trajectory, and it entered the dense layers of the atmosphere and ceased to exist.

Leonid Kizim, Vladimir Solov'yev and Oleg At'kov have completed the third month of their orbital flight. During the days just past, the crew performed a number of geophysical experiments and worked on preparing scientific apparatus for upcoming projects.

The condition of the cosmonauts' health is good, and they are feeling well.

The flight of the orbiting complex "Salyut-7"--"Soyuz T-11" is proceeding normally.

FTD/SNAP

CSO: 1866/148

TASS REPORTS LAUNCH OF 'PROGRESS-21' CARGO SHIP

Moscow TRUD in Russian 9 May 84 p 1

[TASS Report]

[Text] In accordance with the program of insuring the futher functioning of the orbiting scientific station "Salyut-7", an automatic cargo ship, "Progress-21", was launched from the Soviet Union on May 8, 1984, at 2:47 a.m., Moscow time.

The purpose of the ship's launching is to deliver materials which are subject to depletion and various cargo items to the orbiting station.

The "Progress-21" ship was placed into an orbit with the parameters: maximum distance from the Earth's surface—264 kilometers; minimum distance from the Earth's surface 193 kilometers; period of revolution—88.7 minutes; inclination—51.6 degrees.

According to telemetry data, the onboard systems of the automatic cargo ship are functioning normally.

FTD/SNAP

CSO: 1866/148

'PROGRESS-21' DOCKS WITH 'SALYUT-7' STATION

Moscow PRAVDA in Russian 11 May 84 p 1

[Excerpt] The automatic docking of the "Progress-21" cargo ship with the manned orbiting complex "Salyut-7"--"Soyuz T-11" was accomplished on May 10, 1984, at 4:10 a.m., Moscow time.

The cargo ship docked with the station on the side where its equipment compartment is located.

The "Progress-21" ship delivered into orbit fuel for the station's combined engine assembly, equipment, instruments, materials for conducting scientific research and for the crew's life support, and also mail.

According to the crew's reports and telemetry data, the onboard systems of the scientific research complex "Salyut-7"--"Soyuz T-11"--"Progress-21" are functioning normally.

Cosmonauts Kizim, Solov'yev and At'kov are feeling well.

FTD/SNAP

CSO: 1866/148

COSMONAUTS BEGIN UNLOADING 'PROGRESS-21'

Moscow KRASNAYA ZVEZDA in Russian 12 May 84 p 1

[TASS Report]

[Text] Flight Control Center, May 11. The prolonged orbital flight of Soviet cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov is continuing.

Today, a substantial portion of the crew's working day will be spent on unloading the transport spaceship "Progress-21". Containers of products, equipment for life-support systems, and apparatus and materials for conducting scientific research are being moved by the cosmonauts from the ship's cargo compartment into the station.

The day's schedule calls also for a series of experiments for evaluating parameters of the atmosphere near the orbiting complex, routine work on the station, and physical exercises.

A medical examination of the crew was performed yesterday. According to the results of this examination, the condition of the cosmonauts' health is good, and they are feeling well.

The onboard systems of the orbiting complex "Salyut-7"--"Soyuz T-11"--"Progress-21" are functioning normally. The parameters of the complex's orbit are: maximum distance from the Earth's surface--319 kilometers; minimum distance from the Earth's surface--277 kilometers; period of revolution--90.4 minutes; inclination--51.6 degrees.

FTD/SNAP

CSO: 1866/148

MEDICAL RESEARCH IN FIRST 100 DAYS OF 'SALYUT-7' FLIGHT

Moscow MEDITSINSKAYA GAZETA in Russian 18 May 84 p 4

[Article by V. Pishchik, correspondent]

[Abstract] The article records comments of Doctor of Medical Sciences Ye. B. Shul'zhenko, member of the board of the USSR Ministry of Public Health, on the medical research portion of the first 100 days of the mission of comsonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov on board the orbiting station "Salyut-7". Shul'zhenko is identified as one of the directors of medical support for the mission.

Shul'zhenko reports that during the 100 days, 17 medical experiments were performed for the purpose of further studying effects of space-flight conditions on the human organism. Many experiments were performed more than once. A portion of the experiments continued research begun on previous missions, including studies of the cardiovascular system, the space form of motion sickness, and metabolic processes. An experiment called "Sport" is said to employ new physical-conditioning regimens using the exercycle and the running track, for the purpose of preventing adverse effects of weightlessness. As compared with earlier ones, these regimens consume less time but are more intensive in terms of exertion. The continuation and improvement of research in this direction may permit the shortening of time that crews must spend on conditioning exercises.

Shul'zhenko mentions that cosmonaut-physician At'kov's participation in the current mission has made it possible to use a new procedure for functional tests in which negative pressure is applied to the lower half of the body. Whereas the maximum rarefaction produced in tests of this type during previous missions did not exceed 35 millimeters of mercury, the rarefaction level has been brought up to 45 millimeters of mercury under At'kov's supervision. These tests and cardiographic studies are being done for the purpose of more fully evaluating reserve potentials of the cardiovascular system at various stages of a mission.

For the purpose of determining the condition of the cosmonauts' hormonal systems, water-salt metabolsim and blood systems in the course of the mission, blood samples have been taken for the first time from veins with the aid of the "Biokhim" instrument. At'kov has been making routine analyses of a

number of biochemical indicators. A glucose-load functional test was performed for the purpose of evaluating features of carbohydrate metabolism. At'kov also has carried out a series of psychological and santiary-and-hygienic studies, and he has performed a number of otorhinolaryngologic examinations and studies of the fundus of the eye, which have yielded the objective data on dynamics of the blood supply of the rhinopharynx, the tympanic membrane and the eye during various periods of adaptation to weightlessness.

FTD/SNAP

CSO: 1866/148

TASS REPORTS COSMONAUTS' FIFTH EVA TO INSTALL SOLAR PANELS

Moscow PRAVDA in Russian 20 May 84 p 1

[TASS Report]

[Text] Flight Control Center, May 19. Cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov have been working for 100 days on board the orbiting scientific station "Salyut-7".

In line with the mission program, the crew's commander and flight engineer have made a fifth egress into open space and installed extra panels on the station's second solar battery.

The installation of extra solar batteries was planned during the development of the "Salyut-7" station, for the purpose of increasing the capacity of its power system. This work was begun by Vladimir Lyakhov and Aleksandr Aleksandrov in November of 1983.

Cosmonauts Leonid Kizim and Vladimir Solov'yev opened the outer hatch of the station and went outside on May 18, at 9:52 p.m., Moscow time. The extra solar batteries and necessary tools and accessories in containers were taken by the cosmonauts to the place where they were to work. The cosmonauts installed the first extra solar battery and placed it in operating position using special structural elements, mechanisms and fastening devices.

The solar battery that was being enlarged was then rotated 180 degrees by cosmonaut-research Oleg At'kov, who was at the station's control console, and the commander and flight engineer installed a second extra panel. The solar batteries that were installed are equipped with efficient photocells made of gallium arsenide.

After completing the planned installation and assembly operations, Leonid Kizim and Vladimir Solov'yev returned to the station. The time spent during their work in open space was three hours and five minutes.

During the performance of this complex work in open space, the crew operated precisely and confidently and displayed high professional skill.

The condition of the crew members' health is good.

Five egresses into open space, totaling 17 hours and 50 minutes, have been made by cosmonauts during a single mission on board an orbiting station, for the first time in world practice.

FTD/SNAP

CSO: 1866/148

AIMS OF COSMONAUT SHARMA'S 'YOGA' EXPERIMENT

Moscow IZVESTIYA in Russian 7 Apr 84 p 3

[Article by B. Konovalov: "In the Ocean of Weightlessness"]

[Text] The usual life pattern of earth inhabitants is disrupted in space where weightlessness reigns. The human body has difficulty in adapting to that condition. As a rule, all astronauts at first feel a rushing of blood to their head along with certain vestibular disturbances. Medical specialists sometimes call this general sensation of discomfort "space sickness." This is not a sickness in the true sense of the word, but merely the body's reaction to the absence of the accustomed force of gravity.

Leonid Kizim, Vladimir Solov'yev, and Oleg At'kov, who have now been in space for two months, have long since become accustomed to that state. And now Yuriy Malyshev, Gennadiy Strekalov, and the Indian Cosmonaut Rakesh Sharma are experiencing what medical specialists describe as an acute period of adaptation to weightlessness. For this reason an entire arsenal of medical instruments is being used in order to examine their condition in detail.

The first working day of the international crew aboard the Salyut-7 began and ended with medical experiments. The state of various systems in the body was investigated with the aid of Soviet and Indian instruments.

"I am a most unemployed doctor," said physician Oleg At'kov in a television communication session. "My patients do not complain about anything. I must only make sure they complete all of the medical experiments."

"We feel fine," smiles Malyshev, "But," the pilots joke, " have to give the doctor what he wants."

The cosmonauts are not only studying their physical condition, but are testing various substances which the specialists believe should help control "space sickness." This was the objective of the special "Prophylaxis" experiment. The commander and the flight engineer are evaluating the effectiveness of the variously designed "Pneumatic" and "Bracelet" pinch cuffs that are intended to block blood drainage from the lower half of the body and prevent excessive blood flow to the head.

The cosmonaut-researcher Rakesh Sharma is making the world's first attempt to test the effectiveness of yoga exercises in preventing the unfavorable effects of weightlessness. He has been practicing these exercises on earth one hour daily for one and half months, and is now doing them aboard the orbiting station on an integrated trainer which the Soviet astronauts usually use for physical exercises.

At the flight control center Air Marshal Munk Radzh, Medical Services Director of the Indian Air Force, told journalists that "it is interesting to compare the different physical training systems. We believe that the yoga exercises can reduce cardiovascular system disturbances that occur in weightlessness. This will be tested in flight by instruments. On the other hand, the yoga exercises might prove to be quite effective in controlling the muscle atrophy that develops in weightlessness during extensive flights. The yoga experiment is one of many medical experiments that have been prepared by Indian specialists. We are trying to investigate in detail the behavior of separate systems of the human body in flight. In particular, heart activity is being studied with the help of the portable Vector-Cardiograph instrument which was especially designed by specialists of the Hal firm for the joint Soviet-Indian flight. This is an elaborate instrument that has enabled us to conduct tests that are of considerable interest to specialists, and we are pleased that it has been working well in orbit."

...One should note that all of the experiments that are being conducted in the joint Soviet-Indian flight are of a peaceful nature and are being carried out in the interests of all humanity. Our planet's civilization has reached the point where space research is becoming necessary to all countries. And each country can make its contribution to space exploration.

The central event of the first working day aboard the station was the cosmonauts' conversation with India's Prime Minister INdira Gandhi. She emphasized that his joint flight is a splendid example of peaceful cooperation.

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VISITING CREW'S ADAPTATION TO WEIGHLESSNESS, INDIAN EXPERIMENTS

Moscow PRAVDA in Russian 7 Apr 84 p 6

[Article by A. Pokrovskiy, PRAVDA special correspondent: "A Visit to the Doctors: A Report From Flight Control Center"]

[Text] It took two sentences in the log book to describe the "Jupiters'" entire busy day of 4 April: "Docking and transfer completed. No remarks." We can be certain that such brevity will not be encountered from here on in--the days of scientific experiments, and specialists are awaiting the most detailed information on experiments they had devised from the international Soviet-Indian crew.

As usual in space flights, it must all begin with "a visit to the doctors" or, in other words, with medical examinations. These visits are understandably highly unique--the "patients" remain in orbit while data on the condition of their bodies picked up by telemetry, reports by the cosmonauts on how they feel and television observations of the cosmonauts are processed by high-speed computers and then transmitted to another center--the medical information acquisition and processing center of the Institute of Biomedical Problems. This information is processed by the institute's leading scientists, and when necessary, specialists from other scientific institutions join in. But in this flight there is a doctor aboard the space complex as well.

"I have no work to do as a treating physician," was the reservation Oleg At'kov immediately stated. "These fellows are healthy as horses. But the scientific research can be very interesting: Leonid Kizim, Vladimir Solov'yev and I have adapted to the conditions of space in the 2 months that we have been in orbit, but Yuriy Malyshev, Gennadiy Strekalov and Rakesh Sharma are undergoing what is referred to as the acute period of adaptation. Hence the first experiments are aimed at studying this process."

What does this include? The "Bracelet" (for the arms) and "Pneumatic" (for the legs pressure cuffs to reduce blood flow to the head, "Membrane" to study the mechanism behind salt loss from the body and "Optokinesis," a very ingenious device for determining interaction of man's visual and vestibular apparatus and its influence on appearance of so-called motion sickness.

As we can see, the cosmonauts had plenty to do right from the first day devoted to scientific experiments. Moreover we should consider that the work must go on in weightlessness, where it takes quite a knack just to tune the intrumentation and put on and remove the sensors. Consequently Oleg At'kov's qualified assistance is highly relevant. Furthermore the visiting crew is working at its full capacity as well.

"It has to be this way," Malyshev sighed, "you can't play around when it comes to medicine. Giving the physician what he wants is a standard rule for pilots."

And there are many things that space medicine wants. The subtle mechanisms of adapting the human body to the conditions of prolonged orbital flight, of raising the labor productivity of cosmonauts and of facilitating readaptation after returning to earth. Cooperation among specialists from different countries, which manifests itself especially clearly during international flights, is very important in this area. Preparing for such flights, each participating state furnishes its ambassadors with the best accomplishments of that country's science and technology.

Here is just one example. Just a few years ago specialists of the USSR and Poland introduced the "Opros" [Interrogation] scientific experiment in a flight by a Soviet-Polish crew. In it, essentially, self-assessments made by the cosmonauts are used to study the characteristics of motion in weightlessness, the particular features of performing familiar operations and forming new work habits, appetite and sleep, interaction among crewmembers and so on. Now specialists from India have proposed suplementing the questionnaire with a self-assessment of mood based on 12 different indicators. This will make it possible to reveal the individual features of man's psychological adaptation to life in a space vehicle.

During the day that the medical experiments were being conducted in orbit, reporters met Mulk Radzh, a marshal of aviation and the director of the medical service of India's air forces, at the Flight Control Center and asked him to briefly describe some of the medical experiments prepared by the Indian side.

"I suppose I should begin with yoga," he said, "since this system of exercises is basically peculiar to India, and it will be used for the first time in near-earth orbit. This experiment began back on earth, when Rakesh Sharma performed yoga exercises daily. Five postures or exercises that Sharma will be performing while secured to a treadmill were selected for this space flight. And later on we will compare the results of examining Sharma's body after ground and space training with information acquired from his comrades, Malyshev and Strekalov, who will not be performing yoga exercises. Thus we will be able to isolate the influence of this system of exercises on man in outer space. We feel that it will primarily affect the cardiovascular system."

"How would you define the basic orientation of the medical experiments prepared by Indian specialists for the international flight?"

"Our objective was to study one of the systems of the human body in a consistent way. Our choice fell on the cardiovascular system. In the future we also intend

to study other systems on the basis of the procedures developed during this flight. As you already know, we used ancient Indian exercises--yoga--for this purpose. Modern medical apparatus is at the other pole. I would like to mention in particular a portable vector-cardiograph designed by the KhAL company. It will be used in the "Vector" experiment having the purpose of gathering information on the bioelectric activity of a heart at rest and in a stage of a dosed physical load."

This flight day was nearing its end when the "Beacons" and "Jupiters" re-established communication.

"Commander," Earth asked Leonid Kizim, "how are you managing with a double crew?"

"What's there to manage?" Kizim replied with a sound of surprise in his voice. "Everyone working aboard is a professional who is excellently trained and who knows his job. You can triple the crew if you like, and we'll still work well."

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COSMONAUT BEREZOVOY'S MEMOIRS ON 211-DAY SPACEFLIGHT

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 7, Jul 83, No 8, Aug 83, No 9, Sep 83

[Anatoliy Nikolayevich Berezovoy memoirs: "211 Days in Orbit"; by AVIATSIYA I KOSMONAVTIKA correspondents V. Gor'kov and N. Kon'kov]

[No 7, Jul 83 pp 40-43]

[Text] Pilot-cosmonaut of the USSR, Hero of the Soviet Union A.N. Berezovoy was born on 11 April 1942 in the settlement of Enem in Oktyabr'skiy rayon in the Adyge Autonomous Oblast. After graduating from secondary school he worked for 2 years as a lathe operator at the "Neftemash" plant in Novocherkassk. He graduated with honors from the Order of Lenin Red Banner Kacha Higher Military Pilots School imeni A.F. Myasnikov. He then served in air force units. He is qualified as a military pilot first class and has qualified on eight types of aircraft and logged about 1,500 flying hours. He was enrolled in the cosmonaut detachment in 1970. In 1977 he graduated from the Military Aviation Academy imeni Yu.A. Gagarin. Together with flight engineer V. Lebedev, as commander he completed the longest flight in the history of cosmonautics.

We publish the memoirs of Anatoliy Nikolayevich Berezovoy in a literary record compiled by our own correspondents V. Gor'kov and N. Kon'kov.

On Patrol.

Like many of my comrades I particularly like visual observations. Why is this? It is difficult to answer in one word. I saw, for example, how happy Jean-Louis Chretien was when he was observing his own Brittany and Paris through the port

It must be said that the longer you stay in orbit the more you value normal life on Earth. Any person who has been in space values his own place on Earth

in a new way. He begins to think more, meditate more, and his thoughts become broader and his spirit kinder.

From childhood people are accustomed to commune with nature and it becomes for them a joy and provides a key to the cognition of life. Valentin Lebedev had never before grown plants, but on the station he used to rush off the the "Oazis" installation every morning almost before his eyes were opened. He was growing peas there. Valentin told me many times that it was on this mission that he first recognized the absolute fascination of this occupation.

Recall how in moments of leisure, when we are sitting somewhere in the forest around the camp fire we can sometimes gaze at the fire without noticing the passage of time. And in this attractive contemplation we find calm. You experience something similar out in space as you look affectionately around your "kitchen garden."

Visual observations from space were for us a unique way of communing with our own nature, which brought exactly the same kind of joy as on Earth. From orbit we observed all the seasons of the year; the launch was in the spring, we flew throughout the summer and fall and the start of winter. It was very interesting to trace the way in which our planet moved through the procession of the seasons. At first the whiteness gave way to the the onrush of the greenness, and then gold covered the fields and forests, and then the whiteness again; only now, its frontier was moving in the opposite direction. But in general there was not much time to gaze on the Earth's beauty: we were required to carry out the orders of a number of organizations.

We provided a detailed description of the conditions of the forest masses in the Altay, the Carpathians and Amur Oblast. We participated in taking an inventory of water resources. The length of our rivers amounts to a million kilometers and 80 percent of then are beyond the Urals. But the main subject of study was, of course, Siberia, primarily the zone of the Baykal-Amur Main Railroad Link. We took photographs in order to make more exact the geomorphologica maps of this region and the maps of the tectonic faults, which facilitates the choice of sites for the construction of tunnels; and we offered suggestions on the regions promising in the search for minerals.

The Agronomists.

I said this word and then began to think about it. With what ease it becomes part of the custom in space. Some will be pleased by this name for one aspect of our activities in orbit, others possibly not. But, of course, it is not a matter of names, but one of the practical return obtained from manned spaceflight. I think that we have made our contribution to the repository of agricultural knowledge. On instructions from the scientists we conducted experiments in growing plants on the station and we photographed and observed cultivated crops and cereals in various parts of our country at all stages of development.

First, the work on the station. We tended 10 kinds of plants sown in our "garden": wheat, oats, peas, borage, radish, coriander, dill, carrots and

others. These are regular terrestrial plants that we have become accustomed to in everyday life. But in space it is another matter: you value their place in a new way. And we regarded the appearance of each little leaf, each shoot, as a victory in the struggle against weightlessness. And naturally, this was a source of joy.

We had one unlovely, plain plant about 10 centimers high--arabidopsis. On Earth this weed grows most frequently in quarries and dumps and in the desert. And although this plant belongs to class of higher plants it would have remained obscure were it not for cosmonautics. For the first time in the history of spaceflight a plant sown in space seeded. Arabidopsis has a very rapid cycle of development, as little as a month. On the "Salyut-7" it was included in the "Fiton" system and grown on a special nutrient medium. The plants were isolated from the station atmosphere by filters which stopped the penetration of harmful impurities. After it flowered the pods appeared. Then they opened up and we saw the seeds. There were about 200 altogether.

This success became possible thanks to improvements in the instruments and the experimental method. And although the peas, wheat, oats and other plants did not mature, the space biologists took their first confident step in the genetics of the higher plants. The biological experiments were not only of theoretical but also practical significance. For providing cosmonauts with fresh vegetables is not a simple task for future flights to the planets of the solar system. And, without beating about the bush, we engaged in gardening on our own initiative. We grew radish, borage, various salad plants and carrots. And Svetlana Savitskaya was greeted with an arabidopsis flower grown in the "Fiton."

Our working day lasted from eight in the morning to 11 at night, Moscow daylight-saving time. Almost one-third of experiments involved studies of the Earth. We took about 2,500 sets (each containing six spectrozonal pictures) using the fixed MKF-6M camera, 200,000 spectrums of various objects, and a number of pictures using hand-held cameras and movie cameras. The equipment used aboard the "Salyut-7" was developed not only in the USSR but also in Bulgaria, the GDR and Czechoslovakia. The pride of the Bulgarian specialists was the "Duga-M" electrophotometry system and the "Spektr-15M" multispectral camera; for GDR specialists it was the MKF-6M camera, and for the Czechoslovaks the EFO-1 electron photometer, which we used for about 30 hours during studies of atmospheric dust.

From the pictures taken with the camera equipment aboard the "Salyut-7" specialists are able to determine normal and severe drought on sown areas and waterlogged and dry soils and distinguish the sites of sick and pest-damaged crops. This information is undoubtedly valuable, because data on major outbreaks of plant disease can be obtained from orbit several days earlier than by using traditional methods. And this means that treatment can be initiated earlier.

Why do I remember this? Krasnodar Kray. I was born there, grew up there, left there to live my life. In the Kuban there is a scientific organization that is very interested in questions of the use of space technology for the

needs of agriculture. And when just before the mission I traveled to my native place on leave, the associates of this organization impressed me with their faith.

"Your reports from space," they asserted, "will enable us to monitor the quality of the sowings, top-dress the plants in good time, irrigate them, treat them with pest-control chemicals, select the optimal times for other agrotechnical measures, and draw up an economical strategy for the harvesting."

The specialists stated that they also had some specific suggestions for Krasnodar Kray.

"We are planning to allot several regions for observation," they said. "May we ask you to describe the color range of the fields in these sectors in a very detailed manner and clarify how the 'green wave' moves across the winter crops, and note the boundaries of the high-water marks?"

I very much wanted to help the farmers. Finally, their proposals were included in the flight program. From the very first days we actively observed the regions of Krasnodar Kray. We noted the passage of the high-water marks on the Kuban and Laba rivers. We reported on the different colorations of the fields in Yeyskiy rayon: the row crops were brighter, the winter crops dark and thick. We photographed all the interesting localities. Not sample parts of a field, as they used to do from aircraft, but the actual fields. And this was fine, and I got to know the places. At the same time, or almost at the same time, these areas were also being studied on Earth, using aircraft. In this way experience was gained that in the future will make it possible to set up a space data system providing information on the condition of fields and agricultural land.

Virgin Soil for an Ancient Science.

The need to calculate the time when the Nile would flood led to the development of Egyptian astronomy. The famous pyramids, oriented on the stars with an accuracy that even today gives rise to envy, were the observatories, solar clocks and calendars of ancient times. And the long corridor passing through the body of the pyramid served as a telescope.

The beginning of the 17th century saw the start of a new era in the history of astronomy. The age of observing the starry sky with the naked eye had passed. People began to use the telescope for this. And the first to do this was G. Galileo, who realized the enormous possibilities of the new instrument. Over the next three centuries telescopes were consistently improved. Telescopes unique in terms of their size and accuracy were developed. Notwithstanding, from today's vantage point it can be stated that the volume of information obtained with these instruments is comparable to a single ray of light passing through the keyhole of a closed door. And even this weak ray is, speaking metaphorically, perceived by astronomers only in black-and-white.

The middle of the 20 century. Our generation has witnessed the birth of the next era in astronomy, the very latest. The door into the universe has been

pushed just slightly ajar, and through the narrow crack flows a great stream of information across the broadest electromagnetic spectrum. New disciplines have appeared in science. Astronomy has acquired prefixes like "radio," "infrared," "ultraviolet," "X-ray," "gamma." And still most of the information is lost in the atmosphere of our planet after it completes its long journey through space. The launch on 4 October 1957 of the first Soviet artificial Earth satellite showed that the door into the universe can be opened wider. The prophetic words of K.E. Tsiolkovskiy had come true: "From the moment that reactive instruments are used, at that moment a great new era will begin in astronomy--an era of intent study of the heavens."

One of the "Progress" vehicles brought us a modified "Yelena-F" gamma telescope designed for studying high-energy electrons in near space and measuring streams of gamma quanta on the station itself. The "Yelena" modification made it possible with a simple replacement of individual units to switch quickly from one measurement mode to another. We also took unique pictures. For example, an image of a column of zodiacal light against the background of a constellation against which Venus is projected. The specialists said that we had noticed for the first time the extremely anomalous stratification of the Earth's atmosphere. We managed to obtain an image of luminous clouds lit up by the Sun. From this image it is possible to determine the size of the ice crystals that make up these clouds. We took pictures of the Andromeda Nebula, the Large Magellanic Cloud and other objects for which the specialists required clarification.

The study of cosmic rays is complex in nature. The "Intercosmos-Bolgariya-1300" launched on 7 August 1981 is flying at a height of about 900 kilometers. It has a similar instrument aboard. Measurements are also made from Earth, from mountain tops, at sea level and underground. In the Pamirs and Tyan'-Shan, in Moscow and Yakutsk streams of cosmic rays are caught by unique, large-scale installations (covering an area up to 20 square kilometers). The scientists hope in this way to obtain a profile of the vertifcal distribution of high-energy electrons.

In order to make this approach clear to the lay reader, suffice it to say that on an installation having an area of 1 square meter, a particle entering the atmosphere at an energy of 10^{19} electron-volts can be trapped only once in millions of years. When this kind of particle interacts with others, new fast particles are generated, which in turn also multiply. These cascades become streams of millions and billions of electrons, positrons, gamma quanta, and mesons--a whole atmospheric shower of cosmic rays whose width reaches several kilometers. True, their signals are very weak. Suffice it to say that according to the scientists' calculations, of the total energy received by radiotelescopes over the past 20 years only enough has been captured to heat a teaspoonful of water one-millionth of a degree. Note that only the distant descendants of the "forefather"--the first particle--are recorded not only on the Earth's surface but also at the heights at which the "Intercosmos-Bolgariya" satellite is flying. And we, working aboard the "Salyut-7," also participated in painting its "portrait."

Being Our Own Physicians.

After 3 or 4 days at the station we had completed adjusted, or, as the doctors say, had adapted to weightlessness. Our strength returned and our work capacity was restored. We slept almost as well as on Earth. Weightlessness is unpleasant only for the first few days, and then it even becomes pleasant, evidently because of its ease. And when this feeling of comfort starts it must be disrupted.

In space everything is back to front. On Earth we learned to adapt to weightlessness, and now, when we have established an intimate relationship with it, it turns out that we must not forget about the force of gravity. At present the only way to overcome weightlessness is by physical exercise. How joyful the morning warm-up was on Earth! But here the sweat really runs... And it turns out that exercise on the bicycle ergometer or treadmill is not a pleasant form of rest, in a gymnasium, but exhausting labor on which a great deal of working time must be spent. But we understood that this is the proper way home and we therefore did it without being reminded. If it has to be done it has to be done!

A new medical instrument, the "Aelita," helped us to check the state of our health throughout the entire mission. Its size and fantastic facilities are astonishing. The "Aelita" is a step forward compared with the "Polinom" used on the "Salyut-6." It is simpler to use and cuts down the time needed for medical studies. At the same time it replaces an entire functional diagnostic section of a city hospital and enables detailed investigation of the heart, blood vessels and brain and can take electrocardiograms and write data to the onboard computer. Hooked up with the "Chibis" vacuum suit the "Aelita" makes it possible to study venous pressure, which is a complicated task even in a clinic on Earth. But the instrument's chief advantage is that it not only records individual indexes of the body's condition but conducts a qualitative analysis. It helps in solving one of the most important problems facing space medicine: finding an optimal duration for missions during the course of which a person can work with maximum efficiency using given space equipment.

In weightlessness the flow of blood and lymph, whose basis is water, is redistributed. As as is known, even a 10-percent loss of water is unsafe for a human. This is why during the flight we carefully monitored weight changes. Doing this presents no difficulty on Earth but in space it is more complicated: Earth scales are no good there. The designers had to invent a new instrument, the mass meter. Everything in the new installation is quite unusual. The unusual posture that must be assumed during weighing. The cosmonaut half lies on a platform that is mounted on spring-loaded braces. Firmly resting on handles and footrests for the hands and feet and pressing himself to the platform, he makes his body as rigid as possible. A startup catch is pressed and the system commences an oscillating motion. The frequency of the oscillation depends on body weight. The figures showing the arbitrary units for the period of oscillation for the "platform-man" system are shown on an indicator. These measurements are taken four or five times. Then the indexes are averaged and the weight is determined from a special table.

But we did not use the mass meter only for weighing ourselves. At one time we conducted an experiment on the station to collect the condensate of atmopsheric moisture not in a condensate collector but in a container that was used in the waste-disposal equipment. When it was full the condensate collector was usually thrown away and a new one delivered by the "Progress" replaced it. But the condensate from the waste-disposal unit could be pumped into the empty tanks of the "Progress" and thus make it possible both to save the container and space on the station. And then the freight vehicle could deliver other additional and essential freight into orbit.

And so after the collector was full it was necessary to know precisely how much condensate was actually in it. We determined this with the aid of the mass meter. Valentin first weighed himself together with the empty container and then the full one.

[No 8, Aug 83 pp 40-41]

[Text] The Orbital Cosmodrome.

It was the fourth day of our life in our "star home." In accordance with the program on the third orbital revolution we had started preparations for the launch of the small "Iskra-2" artificial Earth satellite. Such a thing had never been done before. The "Salyut-7" had to become a flying cosmodrome.

The satellite was stowed in one of the compartments. First of all we had to check that its electric power source, radio receiver, transmitter and other systems were operating reliably.

Valentin gently touched the elongated hexahedron covered with the solar panels.

"Good fellows!" he said.

"And who are?"

"I was thinking of the student design bureau in my old aviation institute."

Of course, that is where they had designed and fabricated the "Iskra."

Before the launch it had been checked with a special instrument. The satellite systems were fed power for several seconds. Everything in order! They carefully stowed the "Iskra" in the left airlock compartment--just like a spherical "matreshka" made up of a fixed outer shell and a movable inner shell. We load the satellite into the inner hollow sphere. The front hemisphere is open to receive the "Iskra" while the rear half covers the outlet aperture. We fasten down the inlet hatch and turn the sphere with the satellite so that the aperture lines up with the outlet.

All is ready for the launch. All that remains to be done is eject the satellite using pusher rods. We shall do that before we enter the zone of radio contact for the reception-and-command point at the Moscow Aviation Institute.

Below us is the Black Sea.

"Launch!" The operator at the flight control center sends the command.

Ejected by the springs the satellite starts on its independent flight. We watch it for a long time. On command from a timed program device its antennas deploy and one after another the onboard systems are switched in. There it is, the star "KETs" from the science fiction story by Aleksandr Belyayev dedicated to K.E. Tsiolkovskiy! [KETs being Tsiolkovskiy's initials--ed]

We look through the port and it seems as if the "Iskra" is right alongside--you could reach out with your hand and touch it. And we feel a tenderness for the satellite, as if for a son taking his first steps. But after each revolution around the Earth the distance between the "Iskra" and the orbital complex grows--graphic proof of the effect of the upper atmosphere. The following day we could no longer find the "little star" that we had helped to create against the black background of boundless space.

I thought: how quickly time flies. A hundred years ago K.E. Tsiolkovskiy was getting ready to publish the world's first work on cosmonautics--"Free Space"--and today the youth organizations in the member countries of the student "Intercosmos" programs in Bulgaria, Hungary, Vietnam, the GDR, Cuba, Loas, Mongolia, Poland, Romania, the USSR and Czechoslovakia are participating in experiments by the amateur radio enthusiasts using the "Iskra-2" complex. Pennants with the emblems of the youth unions in these countries are mounted on the satellite. They truly symbolize peace and mutual understanding between the nations inhabiting the Earth.

Later, in November, we launched the "Iskra-3." The satellite's departure and the deployment of the antennas were captured on movie and still film. These pictures were included in the television movie "This Long Road into Space."

Weightlessness at Work.

I remember the laboratory that I went to just before the mission to meet the people who were setting up the technological experiments and to hear their advice on operations with the apparatus. They demonstrated installations that had already worked in space--the "Kristall" and "Magma"--and they showed us the "Korund" installation with which we were to work aboard the "Salyut-7." I cannot vouch for it word for word, but one of the specialists said approximately the following:

"To some extent you know them already. Each of these technological installations has its own tasks to do. Whereas with the 'Kristall' and 'Magma' we tried to investigate the secret of physical processes taking place in weightlessness, for the 'Korund' the task is now broader--to show the way to the industrial fabrication of materials. Do not think that the desire to set up in orbit the production of semiconductor crystals or alloys is some gimmick or whim of the technologists. The national economy needs increasing amounts of pure materials that cannot be obtained on Earth. One example is the electron-beam

ultraviolet laser developed at the Physics Institute imeni P.N. Lebedev, in which a crystal that was made in space is used. Thanks to this the laser has shown record characteristics for today."

After this meeting we had a better understanding of our upcoming work with the "Korund."

On 12 July the "Progress" delivered the installation to the station. We assembled it and carried out the tests. True, we did not immediately manage to set up the operation of the control unit. Recommendations from the flight control center helped to solve this difficult task.

How did we work with the "Korund"? Capsules of a given initial composition were loaded into a drum and the technological program for the experiment was selected from the control panel. The process was regulated automatically without our intervention. Signals from the thermal sensor were fed to a computing device which analyzed them and controlled the process. We monitored its current status from an indicator board showing the parameters of the heat regime. And this could vary between 20 and 1,270 degrees and rates of 0.1 to 10 degrees a minute. At the same time the ampule itself could be moved inside the heated field at rates up to 100 millimeters a minute.

We obtained an 800-gram cadmium selenide crystal 30 centimeters long and 30 millimeters in diameter. But that was not the limit. The "Korund" can make semiconductor materials in quite large batches. We are talking about semi-industrial production. When the station continues its flight in automatic mode the installation is capable of operating without cosmonauts. In this event a drum with 12 wells is used. Before they leave the station the crew members load the samples. The drum rotates according to a set program, loading the ampules into the appropriate heat zone sequentially. All that a crew visting the station has to do is collect the "harvest."

Those developing computers, high-precision instruments, and also television and medical equipment, are looking hopefully toward the "Korund" installation.

Over 7 months we conducted about 300 scientific and technical, medical and biological and national economic experiments.

And You, Geologist...

The great height of the photography makes it possible to obtain fundamentally new information: from orbit the "Salyut" can see the structure of the deep horizons of the Earth's mantle as if through a layer of friable deposits. You involuntarily think of the old story that the geologists tell.

A group of geologists journeyed far to the south of the Urals, deep into the steppe. It was the fall season of bad roads, and the lack of roads hampered the journey. Be that as it may, they had to pack some stones under the wheels, and stones are rare in that flat country. And suddenly one of them turned out to be a druse of rocky crystal. The specialists were surprised but decided to return to the area in the spring. And what happened? They found an industrial deposit of the crystal. Production of the valuable piezoelectric crystal, so essential for modern radioelectronics, was organized.

It would seem that everything was fine, but one thing was confusing: how did the crystal, which is always found in high-mountainous regions, come to be on the steppe? Cosmonautics provided the answer many years later. One glance from orbit enabled the geologists to conclude that the Urals range does not end in Chelyabinsk Oblast but extends further south, but underground.

Looking at the Earth's surface from orbit the trained eye can easily make out the ring formations, large ones with diameters of up to hundreds of kilometers and small ones several kilometers across. The former reflect deep structures in the Earth, while the latter correspond to the boundaries of granite massifs and the outlines of old volcanoes. Our planet's mantle is made up, as it were, of numerous individual blocks. Minerals are often deposited along the fault lines between them.

We transmitted about 40 reports to the geologists. Six geological parties are now working by the Caspian and Aral seas, and also on the shores of Lake Balkhash; they are also studying our data on the presence of major mineral desposits. It is pleasing to realize that my labor, as the poet said, is part of the labor of my republic.

In Open Space.

Following the leads of the Soviet-French crew we started to think more often about going out into open space. Our comrades repeatedly told us about the unforgettable picture of open space and their feelings about it. But we wanted to experience all this for ourselves.

Immediately after the airlock was opened the impression was that of being on a street on a bright sunny day with the ground covered in pure white snow. The kind of light feeling that you have when you go out-of-doors in clear, dry weather. Valentin was amazed at the majestic silence of space, and I was surprised by the "space wind" or, more accurately, the unique "draft" that occurs immediately after the airlock is opened. The fact is that, like a vacuum cleaner, the high vacuum had sucked various particles and air residues from the station. I turned my attention to the cellophane folder containing various instructions. Attached to the wall, it vibrated the whole time. And the pencil in it tried to slide out.

Aleksey Arkhipovich Leonov was in communication with us at that time. It was an interesting conversation. Amazingly, 17 years had passed, but we sensed how fresh the memories were in Leonov's mind about his own work in open space. And the fact that what in 1965 was a sensation and seemed fantastic has today become a regular operation (although in extreme conditions) provided for in the flight program. Such is our stormy space age!

We had rehearsed the operation many times back on Earth, and our last practice session had been just before the launch. It was just a kind of general rehearsal monitored in the flight control center.

The program provided for work on the station surface with instruments and equipment: solar panels, sensors, reference samples of materials that during

the flight had been subjected to the effect of cosmic rays, temperature gradients and so forth. Everything had to be inspected and checked, some units removed, others replaced, new instruments mounted.

Valentin left the station gradually, like in the training sessions in the underwater laboratory. First he peeped out as far as his belt, and then cautiously raised himself up to his full height above the station. I covered him. After he had secured himself to the special point (the "anchor") he set to work. He tested the instrument he was to use to unscrew and screw up the bolts. He did it calmly and methodically, just as if he were in training and not 300 kilometers away from the Earth. He removed some instruments, others he replaced.

The specialists monitored his work nervously. Each part removed from the surface of the station was of interest to them. For example, the "Pamyat'" instrument shows how best to make thermochemical joints for the parts of the pipelines. But how would articles made from stainless steel and titanium alloys behave in space under pressure? The "Resurs" instrument makes it possible to answer this question. Planning for future assembly work in space, the designers hope to enhance the reliability of threaded joints. The "Istok" instrument is for this.

The micrometeorite sensor was of great interest for the scientists. The pitting and dents on its multilayered coating will provide exhaustive information. We remember the story of Vladimir Aleksandrovich Shatalov, of how he observed a real meteor. Of course, an encounter with such an object is very rare. But the smaller ones quite often bombard the covering of our "star house." It has been calculated that in 100 revolutions the "Salyut" encounters up to 200 particles. True, their size is very small, but because of their great velocities the possibility of an encounter cannot be ignored. And the designers have provided special screens to protect the "Salyut."

And what if the covering is still damaged? Will this not mean catastrophe for the crew? The scientists' calculations convince us that the outcome will be favorable. Thus, the air in the "Salyut" will take a day to escape through a perforation the size of a pinhead. If the hole is size of a pencil it will take one-and-a-half hours. Quite enough time to do something about it. Pressure suits can be donned, a docking made by a "Soyuz" with the station, or attempts made to seal the hole with a special plaster.

A few words about the pressure suit--our work clothes for open space. It is a quite complex technical device. The cosmonaut does not put it on but rather climbs into it. Speaking metaphorically the pressure suit is like a thermos flask, since it consists of several layers. The outer layer is a protective-vacuum insulator that provides protection from overheating in the sun and freezing in shadow. The inside is a special sort of flying suit which regulates the temperature inside the pressure suit.

Reserves of oxygen and water, exhaust fans, pumps and other equipment are mounted in the backpack [spinolyuk]. The individual requires no kinds of external communication inside the pressure suit. A tether with a snap lock

on the end is provided, and with this the cosmonaut attaches himself to securing points on the surface of the station. A light filter is used to protect the eyes from the searing rays of the Sun. In all, it is a complete space vehicle in miniature, making it possible to stay outisde the station for up to 5 hours. After returning to the station the pressure suit can be connected to its control panels, thus prolonging the service life of the life-support system.

We were in open space for two-and-a-half hours. Having completed the planned work we went back into the airlock, closed the doors, filled the compartment, took off our pressure suits and went on into the main part of the station.

[No 9, Sep 83, pp 44-45]

[Text] "Vacuum Cleaners" in the Universe.

During the flight we investigated various sources of X-ray and ultraviolet radiation. Interest in these superhigh-energy rays arose during the Thirties when it was hypothesized that X-ray radiation is generated in the so-called neutron stars. This kind of star consists entirely of densely "packed" neutrons. The huge mass, equivalent to or greater than that of the Sun, is compressed by gravitational forces into a "small lump" only 8 or 10 kilometers in diameter.

Neutron stars are the first, and up to now the only objects known to us in the universe that are made up of nuclei alone. The powerful gravitational field of this kind of star acts like a vacuum cleaner. If a normal star enters the sphere of the gravity's effect material is sucked from it. And the magnetic field of the neutron star shapes the sucked-out stream of gas into a jet which beats about its surface in the region of the poles. By being converted into heat, the kinetic energy gives birth to X-ray radiation.

We spent about 50 hours conducting astrophysical observations in the X-ray range using the RT-4M telescope. More than 1,000 pictures were taken of the starry sky. Some neutron stars emit radio pulses that are repeated with an accuracy better than that of chronometers. The first of these cosmic clocks was detected in 1967 by the Englishman A. Hewish. Initially results were classified but a year later were made public. A new word entered the vocabulary of astronomy--pulsar.

In the scientists' opinion, pulsars are rapidly rotating neutron stars. The regions where the streams of cosmic material are falling into them first face toward the observer, and then away from the observer. In addition to the regular radiation, pulsars also emit bursts of radiation. For periods of several seconds brightness increases by a factor of 10 to 30. After a few hours another burst occurs.

What is the nature of these flares? It is thought that material falling on the surface of the neutron star as it were spreads across it. Rich in hydrogen, it burns evenly and slowly, and is converted into helium, which builds up to critical mass; and then a nuclear fusion reaction starts. The temperature

rises sharply. Burning up for fractions of a second, the helium generates an X-ray burst. Then the entire process is repeated. More than 30 of these regularly flaring neutron stars have now been found.

The cosmic objects known as "black holes" are even more powerful "vacuum cleaners." Why have they been given such a strange name? Like a gigantic funnel, a black hole sucks in material from the surrounding space. When it enters the funnel, gas disappears, ceasing to emit radiation. Hence the definition of "black." And the strength of its gravity can be judged from the following fact: any normal star close to it becomes a victim. The black hole sucks material from it. One of these pairs is found in the constellation of Cygnus. Cygnus X-1 is well known to astronomers.

"Then how can they be detected?" you will ask. But remember: when we pour water into a funnel we see that a vortex flow is formed into which the fluid disappears. Something similar happens in space. The captured material gradually starts to turn in a spiral, assumes the shape of a disk, and slowly approaches the neck of this natural funnel. During this time, friction heats the material to hundreds of millions of degrees and X-ray radiation is emitted. And it is this that reveals the presence of the black hole.

The quasars, discovered during the Sixties, today seem even more "voracious." The scientists have calculated that to "feed" a quasar, each year it must be given about 20 bodies like the Sun to "consume."

Cosmic rays at superhigh energies are primarily of interest to all the representatives of two sciences, namely astrophysics and the physics of elementary particles. The fact is that, on the one hand, the source of this radiation could be cosmic objects that are still inadequately studied, such as pulsars, the envelopes of supernovas, black holes, the active cores of galaxies and quasars; and accordingly, information brought by their radiation is very important. On the other hand, this radiation consists of particles at the highest energies known to us, exceeding by factors of thousands and millions the energies obtained under terrestrial conditions in accelerators. This is why the study of these particles is of great importance for specialists in high-energy physics.

Flight and Psychology.

Valentin and I started to train a year before our mission. By then he had already twice been through the training course for long-duration flights. But blind chance had prevented him from flying earlier: just before the launch he damaged a knee during training on the trampoline, and Valeriy Ryumin went on the 185-day mission. When our crew was formed I was naturally glad that I would be going with a man who had a splendid knowledge of the equipment and also experience of work in space. I liked Valentin's engineering intuition and his persistence and exactingness both toward himself and toward others, and his open and honest character.

During training we set ourselves a target: we would map out all the "hidden rocks" that we would perhaps bump into in orbit. The "Salyut-7" station was

crammed with apparatus. Each instrument, system and experiment had to be thoroughly studied. And, of course, there were some psychological difficulties. I am no longer a lad, and everyone has his convictions and habits, his own style of work. And sometimes they do not coincide. But we quickly found a common language. We immediately agreed that in the work there should be complete frankness. By launch time we knew each other probably as well as each knew himself, and we could soberly assess our achievements and shortcomings. I began to be stricter, both with myself and with others. When during the training process we encountered something that had not been thought through in the methodology or the documentation, we raised the basic question of eliminating the defects as quickly as possible. I remember that some comrades started to take offense at me for allegedly greater faultfinding. But I had already realized that the attitude of forgiving your "partner" for everything only hampers things. I was constantly worried by the thought that many of the operations in the program were having to be done for the first time. If any kind of deviation occurred it was essential to analyze the situation rapidly and make the correct decision. Space is a strict taskmaster. This is the essence of the profession of cosmonaut: he is trained for any situation, but during an actual mission he does not always encounter them.

Popov, Ryumin and our other comrades who had completed long-duration missions told us that on a long flight it is twice as difficult. Sometimes even critical situations arise. How to resolve the crisis in mutual relationships in such cases? Being constantly occupied and working had helped. I was convinced that patience and a real desire to understand what is going on often simplifies a situation.

Valentin and I had a very short and very intensive period of training toether. And so some questions of our mutual relationship were simply not solved completely successfully. We had to deal with them in space. Those who follow us, of course, will do it no better. And one other consideration. It is advisable to form crews in such a way that the merits of each member are complemented while the defects are smoothed over. If this is done a crew will be strong and capable of going further than we did.

During a long mission it is essential to be endlessly patient: the proper tone must be set in conversations with the ground and in your relations with your comrades. One feature of our profession is that we are always on view. It happens that when you are speaking with the specialists at the flight control center you sometimes forget that you are also being heard by dozens of other people. Sometimes not everything in the conversation is understood and they hear only the tone, and they get the wrong impression: the cosmonauts are irritated, giving trouble. If fact, of course, nothing of the sort is happening. The conversation had to do with business, and here other intonations are possible.

During a mission the crew carries out the most diverse kinds of work and it has a lot on its plate. And if something suddenly breaks down it is very easy to take the attitude of, well, it is not my fault. Of course, no one is about to blame you, and you are, in a way, out of it all. It is easier to blame circumstances. But the thought is always gnawing at you: when you get back to Earth will you see it the other fellow's way if you have indulged

yourself? For some experiments are prepared by an entire collective. You do something not quite right, and years of work are lost. This is why we sometimes worked at full stretch for 14 or 16 hours a day, surpassing ourselves. Discipline is very strict, you cannot weaken. Just fail on one command and all the work done by you and by others could be for nothing. On Earth you often do not see the final result of your own labor: this dependence is covered, hidden. In this case everything depends on your conscience. But in space both your work and your conscience are on view for all, and you cannot hide behind others.

The mission gave me a great understanding of how to relate to a colleague's idiosyncrasies and keep myself firmly under control. I think that on the purely human plane the mission gave me a great deal for the future. It was difficult, of course: I missed my nearest and dearest, everything on Earth, even the everyday bustle of Earth. We had various kinds of taped recordings: concerts, popular music. But by the end of the flight what we listened to most was Russian songs. We also had recordings of sounds: thunder, rain, the singing of birds. We switched them on most frequently of all, and we never grew tired of them. They were like meetings with Earth.

The Return.

The 211 days were behind us. The time had come to bid farewell to the "Salyut." It was not not as joyful as we had thought. I had mixed feelings. On the one hand was the desire to go home. On the other a sense of dissatisfaction: it seemed that on such a long mission more could have been done. Yes, during those 7 months the station had become home. But--it was time!

As we were transferring to the "Soyuz" we suddenly asked each other: have you forogtten anything? The question was by no means facetious. Many years of work by many people had gone into the station. And now each of them was waiting for his own share of the information we had obtained.

We completed the check to insure that that docking assembly was sealed. We wrote on it: "This is not goodbye!" We reported to the flight control center.

"'Zarya.' Undocking complete. We are moving away from the station."

"Bon voyage! We are waiting for you here on Earth. The search and recovery services are ready. The landing region is being made more precise..."

And then the voice of the flight control center operator again: "'El'brusy.' It is night now in the landing zone but the weather looks hopeful: wind 6 meters per second, 15 degrees of frost, visibility 10 kilometers. Incidentally, the steppe there is quite soft, much snow has fallen. It should be a soft landing."

A night landing after such a long flight. This was explained only by technical constraints. The fact is that two conditions should be satisfied when the braking engine is switched on: light in orbit for controlling the orientation of the vehicle and landing no later than 1 hour before sunset so as to facilitate the search and evacuation of the crew. On our mission, unfortunately,

these conditions did not coincide. As they say, it was a question of the lesser or two evils. The more important thing was light in orbit. In any case, our search and recovery people have experience in picking up crews at night.

Up to that moment everything aboard had gone well. The automatic system had operated and the reentry vehicle had moved into a controlled descent trajectory.

We tear into the atmosphere like a fireball. The glass in the ports is crisscrossed with the red filaments of plasma. We are flying in a fiery sphere. Communications with Earth are interrupted.

After the light we find ourselves in darkness. Throughout the entire mission we had dawns and sunsets 16 times a day. Now, out of habit we are expecting to see the bright Sun again in a cloudless sky at any moment. But there was no Sun. A snowstorm was raging in the black gloom of the Dzhezkazgan steppe. The weather had given us a surprise. The predictions of the meteorologists notwithstanding, some of the warm air had moved into the open spaces of the steppe. Complex weather conditions had formed: low cloud, fog, and then a snowstorm, with soft, fluffy snow.

I remember the interest with which we listened to the helicopter commander N. Karasev telling us about the actions of his crew, which was the first to put down near our vehicle. I am amazed now at his courage and flying skill! He repeatedly tried to land but each time he finished up in a snow bank up to his rotors. Even his headlights did not help. And the search leader gave him permission to set his aircraft down at his own discretion.

There were 10 people aboard the helicopter. Karasev realized that he was taking a risk but he still assumed the responsibility for the outcome of the flight and he landed; because he knew that all 10 of them, himself included, were burning with the desire to help us. The helicopter landed with what in flying circles they call a short landing run. Thus, help came, and quite quickly.

The search and recovery installations with physicians aboard also reached the landing site. They came across the steppe at night, with no roads. They arrived and made our first hours back on Earth warm and pleasant.

I express my great thanks to all those who met us and warmed us on that dark and frosty night!

Meanwhile, the weather was deteriorating. However, it could not spoil our mood. It is difficult to put into words how wonderful it was just to be earthmen again. And the circle of happy, smiling faces. I would like to embrace and kiss them all

Of course, 211 days under weightless conditions leave their marks on the body. Immediately after the return from space it was difficult for me not only to walk about but even sit. During those 7 months some muscles had grown unaccustomed to fulfilling their normal function on Earth. I had to lie down and rest before standing up and starting to move about. At first I went to the swimming pool quite often. It helped me to stand. On the third day I was permitted to go over to the dining room and by New Year I was already home, in Zvezdnyy.

Now we are enjoying a normal life and enjoying the feeling of wanting to go back into space to work.

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EXCERPT FROM COSMONAUT ALEKSANDROV'S FLIGHT DIARY

Moscow IZVESTIYA in Russian 4 Feb 84 p 3

[Excerpts from the diary of Pilot-Cosmonaut of the USSR Aleksandr Aleksandrov: "Earth, Wait for Us!"]

[Text] The flight of Valdimir Lyakhov and Aleksandr Aleksandrov in near-earth orbit lasted 150 days. Our newspaper reported in detail on the progress of the flight. Now we have a thick, worn notebook covered with small handwriting--the flight diary of a cosmonaut. You open it and it's as if you are taken on board the space complex.

27 June 1983. We arrived at the assembly and test building to get dressed. We had coffee, sandwiches and salad. After we donned our space suits, the news photographers took our picture through the glass. We went to the building's exit 2 1/2 hours prior to launch for a briefing. The launch directors wished us a happy trip. Seated beside us in the bus were the back-ups, Dr Ivan Matveyevich and A. A. Leonov. While we rode, the remaining small articles and envelopes, which later will be space souvenirs, were distributed in our pockets. The launch directors were waiting at the rocket. We embraced and went on to the elevator.

We entered the ship. It turned out that we had violated tradition: usually the gloves are left behind here, upon entering the ship. But we gave them to the back-ups in the bus.

We settled into the descent module and the preparation passed with no problems. Volodya said: "We're off!" I also felt how the rocket shook. Good-by, Earth!

Things were going smoothly, then we heard a noise--the nose shroud separated. Light immediately gushed in the windows. The strap-on boosters finished operation smoothly also. The rocket hesitated a little, then the second stage began. The ship shuddered and we felt the acceleration. The second stage separated rather noisily. We immediately felt the strong thrust of the third stage and the jolt on our back.

We sensed the weightlessness, the clocks were turned on and the globe started. I found time to look out the window. The continents and ocean are floating. The impression is that you are flying backward and upside down.

We entered the crew compartment and removed our space suits. We drink a lot--fruit juice diluted with water. Evidently this counteracts psychological stresses. I settled down to sleep in the crew compartment and Volodya in the descent module. But then he got cold and came to my compartment.

28 June. At a distance of 12.5 km we saw "Salyut-7" on the screen. Now parts of the station were already visible--the "cross" and the lights. Then we felt a jolt--it was perceptible that the two massive bodies had converged. And we docked. Two orbits later Earth authorized opening of the hatches.

In the docking unit we sensed the odor of burnt steel--the odor of space.

We reported to "Zarya" on our readiness to transfer to the station. The air is clean in the station. We immediately began to reactivate it and initially even forgot that we had to deactivate the transport ship.

29 June. In the first two days of flight only the headache that came about after the docking, a hard day and a restless night in the crew compartment was unpleasant. It became easier later, but there is a feeling that something is different than on Earth. There is no playfullness or the usual train of thoughts and movements are constrained.

After the first physical exercises there emerged a heaviness in my head and my overall condition was not pleasant at all.

I was very thirsty. The water was good, clean and cool. You work the pump and put the mouthpiece in your mouth...

1 July. The station is taking on an increasingly working appearance. The book on astrophysical experiments and instructions on motion pictures and on working with the "Yelena-F" telescope are under pieces of elastic. Above are charts of the stars and biospheric reserves. Closer to the transfer compartment hatch are small film bags.

In the same place there are letters and Serezha's drawings in a plastic packet. I still have the two toys. Natasha asked the children to get together some presents for their dad, but with the condition that they be small. Serezha found a teddy bear and Irishka sent a small doll. I still have the dired violet which they sent from home before the launch.

I use the seat at the first station with the back forward: I clasp the leg with my legs add can turn completely around from one table to another.

5 July. Today is the first training session and I ran for about 35 minutes and then did exercises. You get warm quickly, the face and arms sweaty and by the end of the training you are soaked. But the legs are dry. Then we sponge down with a warm, damp towel. The perspiration is not salty, but rather bitter. But you are thirsty just like under earth conditions.

When we were unloading the "Cosmos" we found a sealed silvery packet. It turned out that this was eleutherococcus [R. eleuterokokk]. We were so pleased. This is an invigorating liquid. Thanks to the doctors who placed this present here.

In the evening Valentin Lebedev was in contact.

6 July. A very full day. Much time was spent fixing the tape-winding mechanisms of instruments.

Today is a holiday--I received a letter from Natasha via teletype. More joy--we turned on the video recorder for the first time. We watched a concert at our "Ogonek" and a performance by the group "Abba".

Little by little rhythm of life is settling in, a daily routine. We found dried apricots. And it's as if it's closer to earth life. But there is something that separates it from the usual, earth way. Everything is remembered as if it was very long ago and we are not together and it is not known when it will be again.

We feel pretty good. The muscles ache a little. Again I notice flashes with my eyes closed.

7 July. In the morning we talked with the first people to cross the northern tier of our continent. They travelled 250 days by dogsled.

In the evening we watched a few more video cassettes. We have the history of the movies, hang-gliding, bits of "Kinopanorama", variety and musical comedy. Still there are not enough tapes.

8 July. Something happened which, although annoying, was instructive. We found a cable similar to the one needed for the shower unit. We started to install it, but it was not the right one at all. We cut off the connector so that it fit the receptacle. Then it turned out that it was meant for entirely different purposes. In the future, when we have doubts, we must certainly consult the Center.

9 July. We conducted a geophysical experiment and then talked with our families. Serezha "lost" a tooth. He tried to explain that they had harvested the crop on the balcony: one small cucumber which he and Irisha ate. Zina and Olya, and Natasha and Serezha told of family news. Mama is feeling better. Perhaps they are reassuring me with this. Natasha said that all our friends were over to our house. They said many good words and promised to come again after our landing. We received many telegrams. It was especially nice to find out about the congratulations from Ye. S. Poliyevskaya, my class instructor from the Zagoryanskaya School.

These encounters, of course, do not go by calmly and the effect remains right up until you sleep. It is already midnight and we still haven't turned out the light. The tape recorder is on and Volodya is reading Gamzatov.

Today we had an excellent view of the Crimea, the Causasus and South America with its big rivers and ports.

10 July, Sunday. We slept until 10:30. Natasha sent another letter, but it's a bit shorter. The main thing is that they are with us. Our families

went to the country. We were busy taking pictures and photographed many interesting things. We changed underclothes and I gave myself a scrub-down with hot water. You pour the hot water on the towel and rub. It turns out pretty good. We watched the broadcast "Today in the World". Tomorrow rising time is 7:30 and we are going to bed a little earlier.

15 July. It's hard to wake up. My hands and fingers ache. I worked a lot with them yesterday. My fingers have many hangnails. The fingernails are weak and break.

Yesterday was the 12th anniversary of the launching of the ship "Kosmonaut Yuriy Gagarin". We congratulated them and they gave us a concert.

Today Irina napped in the nursery and played a little with the children. She is getting accustomed to the collective.... This report cheered me up for the whole day.

16 July, Saturday. We slept until 8:00, made contact and, with Earth's permission, went back to sleep. Today it is allowed.

In the afternoon we set up the experimental solar sensor and did some trivial things. We did not exercise. Volodya is reading Gamzatov before sleeping and here I am writing.

It is getting increasingly difficult to move around the working compartment--cases of food and various equipment are everywhere. And we still haven't taken out the containers with the additional solar batteries from the "Cosmos" or more than 10 other large units.

17 July, Sunday. Starting in the morning, we worked with the solar sensor and then had a TV communications session. As things went on we replaced the waste tanks and set up the dust collectors.

We passed South America and Argentina. The high mountains can be seen very well. The air is clean, therefore the picture is clear. Volodya says even that he saw individual houses. There is a haze over the valleys....

19 July. For the first time I saw noctilucent clouds before the sunrise over North America, on the side of Greenland. There is a very bright white strip at about 500 km, then the soft, sky-blue atmosphere and--Earth. We took four pictures.

Tomorrow is Volodya's birthday. In the evening, when we were eating, I handed Volodya a medal which I brought on board and on its reverse was written: "Aboard the Complex, Oribt 7222". This is the pass which will be at 9:00 tomorrow morning. He was born in the morning. Together with the medal, I gave him some poetry which a comrade had written before the launch at my request.

20 July. We accept congratulations from Ryumin, Beregovoy, Popovich, Malyshev, Berezovoy and Zudov. Seyful'-Mulyukov directed the broadcast from

the Ostankino. Zina and Olya, Natasha, Serezha, mama and Volodya's closest friends all said a few words each. The ships "Kosmonaut Yuriy Gagarin" (KYuG) and "Kosmonaut Vladimir Komarov" congratulated us in verse and the "KYuG gave a concert. In the evening Volodya and I sat down to a festive table. In the evening "Mayak" reported on our holiday and the day of geophysical research. Answering questions, Volodya said that we also have our difficulties. I added that we must believe that we will overcome them and not lose our sense of humor.

The bright light from the clouds is very annoying through the windows. The eyes hurt and are watering.

21 July. We get very tired by the end of the day and our nerves are no longer like in the morning. Now it is already after midnight and Volodya is still rumaging around. We awaken fresh, but with reluctance. Today I observed the Falklands and yesterday Madagascar. We flew over the two Americas on a downward pass. We began filling a bag with the initial results for the return--tapes and cases.

22 July. We spent a long time putting things in order.

It is time to begin writing letters home and to friens--we will soon launch the return vehicle of "Cosmos-1443".

23 July, Saturday. I did some soldering. Tin solders just as on Earth, except that it takes on a spherical shape if it comes off the soldering iron. And it can get in the eyes, which happens quickly. The trouble with soldering is there is no heat dissipation.

24 July. We unloaded "Cosmos-1443". We pass on what to bring us: tapes, coveralls, flash bulbs, spare parts, and, of course, fruits and vegetables, onion, garlic and mustard. Volodya cleaned with a rag the whole day.

During the communications session, we heard something seemed to knock against the right side. Then we saw a dark spot on the window above. It turned out to be a crater from a micrometeorite. We realized that the knock was the impact on the glass.

We began to transfer large units from the "Cosmos". For arrangement of the containers with the additional solar batteries, we had to saw off one of the handles.

For quite some time we forgot about the knock on our window. Later on, we concluded that it is nothing terrible. The probability of our colliding with a larger particle is very low.

27 July. We congratulated each other on the month of flight. We are going to bed late and at 00:30 are still not sleeping. We saw a grand sight through the windows of the "Cosmos" with a view of the orbital unit and the panels of the solar batteries. We took several pictures when between the panels was the Earth and later on the stars. Next we observed the night ocean for a while with its mass of lights.

28 July. We labored intensely from 0830 until 2300. We performed a great many experiments. The first was with a microaccelerometer. And how annoying: the experiment had just begun and a fuse burnt up. While we were changing it, the allotted time ran out. Then we prepared the "Kristall" for operation, conducted a TV report and worked with the "Astra" apparatus.

Here all the processes in our organisms are sort of slowed down--for example, the growth of the nails on the hands and feet. But here in the "Oasis" in five days the stalks of dwarf wheat shot up to 5-7 centimeters in length. It is pleasant to watch the greens; they are our nurslings.

I am writing and next to me in photographs are all those near to me. In difficult moments I think of them....

> The first month of flight has come to an end and the flight notebook of the diary is concluded. Aleksandr Pavlovich promised that he will soon pass on to "IZVESTIYA" excerpts from subsequent entries.

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RESULTS FROM 'ASTRON' SATELLITE AFTER ONE YEAR IN ORBIT

Moscow PRAVDA in Russian 23 Mar 84 p 3

[Commentary by Academician A. Severnyy and corresponding member of the USSR Academy of Sciences A. Boyarchuk: "Dissimilar Characteristics of Stars in Ultraviolet Region of Spectrum"]

[Text] A year has elapsed since the 'Astron' experiment--a stage in Soviet astrophysics and astronomy. What has the unmanned research laboratory contributed to science?

It is well known that notwithstanding the power of modern charged particle accelerators and facilities for studies of atomic nuclei, the condition under which matter is encountered in the universe cannot be reproduced on Earth. Physical processes in the Universe are accompanied by the release of enormous quantities of energy, immense explosions and ejections of matter. It is possible that many concepts and theories of physics will be reformulated more accurately and conceived on the basis of an analysis of new astrophysics discoveries which will further contribute to the advancement of basic sciences.

Most physical processes in the Universe can be investigated in the invisible portion of the electromagnetic radiation spectrum, in the ultraviolet, x-ray and gamma-ray regions. These rays do not reach an observer on Earth because they are absorbed by the atmosphere. They cannot be investigated on the surface of our planet. Therefore spacecraft must be used to launch scientific measuring instruments and equipment into space. This was the reason for the great interest of scientists and the entire scientific community in the launching of the automatic 'Astron' satellite-laboratory into space on 23 March 1983. The first large optical telescope produced in our country for recording the spectra of stars and other celestial bodies in the Universe in the far ultraviolet region (wavelength 0.1 to 0.35 micrometers) was mounted on this satellite-laboratory. This telescope is the largest telescope launched into space in the USSR and abroad. The telescope is about 5 meters long and the diameter of the telescope is about 1 meter. A telescope-scintillation counter for recording x-ray radiation in the wavelength region of several tenths of one nanometer was also mounted on the 'Astron' satellite-laboratory.

The launching of the 'Astron' satellite into an orbit with a high apogee (200,000 km) solved a number of difficult and important scientific-engineering problems, such as aiming the telescope and stabilizing its position after it was locked on a star with very high accuracy (small fractions of a second) during a 3-8 hour observation period (one second of arc is an angle at which a human hair is visible at a distance of 50 meters!). Light precision mirrors which quickly restore their mirror figure, furnished with special coatings that reflect well ultraviolet radiation, were developed for the first time. The housing and the mechanical part of the telescope, which can withstand heat deformations and strains, were worked out in detail. A complex set of electronic equipment was developed for acquisition of scientific data and control of the operation of systems on board the satellite. All this required special technology and careful testing and verification of equipment before the launching, because even a minute malfunction could doom the entire experiment to failure.

The complete intactness of the opto-mechanical device of the telescope, the reliable functioning of the focusing, aiming and stabilization systems, the closeness of all optical parameters to the values that were determined during tests on ground were already demonstrated in the first few trial operations of the ultraviolet radiation telescope in orbit. This confirmed the correctness of the engineering solutions which served as a basis for the development of this high-precision space telescope designed for optical studies in an automatic mode. The same statement can be made about the x-ray telescope scintillation counter.

The work that went into the development, verification and testing of the telescopes and the entire configuration of equipment, during which many difficulties had to be surmounted, was the result of the joint efforts of the Crimean Astrophysics Observatory of the USSR Academy of Sciences, the Byurakanskaya Astrophysics Observatory of the Armenian SSR Academy of Sciences, the Institute of Space Research of the USSR Academy of Sciences and a number of industrial scientific-production associations. In addition, it should be mentioned that the ultraviolet radiation telescope was developed in collaboration with the Crimean Astrophysics Observatory and the Satellite Astronomy Laboratory in Marseilles with the active assistance of the advisory council of the Intercosmos organization. Besides the postulates proposed by the authors of this article, several basic postulates which determined the idea of this experiment were proposed by Academician Ambartsumyan, corresponding member of the USSR Academy of Sciences I. Shklovskiy, corresponding member of the Ukrainian SSR Academy of Sciences V. Kovtunenko and others.

The 'Astron' satellite-laboratory and all scientific and control instruments and equipment on board the satellite have been operating without interruption for one year. The latter made it possible to obtain a number of important scientific results in basic directions of research: the investigation of non-stationary phenomena in stars (ejections and absorption of matter, explosions of stars), anomalies in the chemical composition of stars, properties of ultraviolet radiation of galaxies and quasars and other characteristics.

The greater part of normal stars shows no signs of intense ejection of matter; however, the outflow of matter from hot stars occurs at tremendous speeds, often exceeding thousands of kilometers per second. Enormous masses of matter are ejected--hundreds of billions of tons per second. The hotter the star, the greater the mass of ejected matter, the higher the outflow region of matter on the star, the greater the speed of the ejection. This fact is of key importance for an understanding of the processes involved in the formation of gaseous dust nebulae in our galaxy. New stars are then formed from these nebulae which enables us to explain the cycle of matter in the Universe.

Great attention has been given to an investigation of nonstationary stars whose brightness varies continuously as a result of explosions. Typical representatives of this class of celestial bodies are dwarf novas. They flare up in intervals on the order of one month, that is, the brightness of the star increases suddenly about tenfold. It has been known for some time that the latter are systems of two celestial bodies and that the principal component of such a system is a cold dwarf star. Practically no data were available to science about the second component. Thanks to observations above Earth's atmosphere, first-hand data about these systems were obtained for the first time. It turned out that the second component is a hot source with emission temperature above 60,000 degrees and that the dimensions of this source are very small--less than one hundredth of the radius of the Sun. Because the emission temperature of a normal star of such negligible dimensions must be much lower, it is clear that we discovered a new phenomenon which is not a part of the body of existing scientific knowledge. The so-called accretion of matter mechanism was proposed to explain this phenomenon. Essentially, it involves the following processes: matter ejected by a star is captured by another star under the effect of gravitation. While falling, matter collides with gases surrounding the neighboring star, heats up intensely and a conversion of gravitational energy to radiant energy occurs. The small dimensions which had been determined from observations correspond to the active zone in which this conversion primarily occurs.

Recently astronomers have become increasingly more aware of the fact that accretion processes are ubiquitous in the Universe and that they are accompanied by the release of enormous quantities of energy. Symbiotic stars are another example of an accretion process. The dimensions of these binary giant stars are thousands of times greater than those of dwarf novas. Their principal component is a cold star which is about one hundred times larger than the Sun in our solar system. We also had no first-hand data about the second component of such systems and were only able to obtain them as a result of observations carried out in space. On 29 December 1983 observations of a symbiotic star in the constellation Andromeda were carried out from the 'Astron' satellite. The observations proved conclusively that the temperature of the second component exceeds 100,000 degrees. Only accretion processes or nuclear reactions (fusion of hydrogen nuclei) can generate such a high temperature. The burst of x-rays observed with the aid of the x-ray telescope mounted on the 'Astron' satellite is also related to accretion processes. However, here we are dealing with a qualitatively different phenomenon--matter impinging on a neutron star--an amazing formation whose density is several billion times greater than the density of water. Various types of these bursts, which are still not understood, are of great scientific interest.

The anomalies in the chemical composition of stars detected from the 'Astron' satellite-laboratory, in particular in a star with a high lead, tungsten and uranium content (exceeding that of the Sun by more than a hundred-fold) are very important, since they indicate the special part played by nuclear processes leading to the formation of these elements. These anomalies cannot be explained by the capture of slow neutrons by atoms of lighter elements.

Measurements of ultraviolet radiation of the remnant of an immense explosion which occurred tens of thousands of years ago (so-called Loop Nebula in the constellation Cygnus) by instruments mounted on board the 'Astron' satellite-laboratory demonstrated that it was produced by hot plasma of the residual shock wave and induced by highly ionized carbon, oxygen and helium atoms.

Ultraviolet radiation was also observed around about 20 different types of galaxies. Galaxies are vast formations made up of billions of stars and enormous masses of gas and dust. The lifetime of galaxies is estimated in tens of billions of years, and it is completely beyond the capacity of mankind to trace the evolution of a particular galaxy. This evolution can only be inferred by comparing the characteristics of galaxies of various ages. Here observations in the ultraviolet region gave unexpected and qualitatively new data. The point is that while many galaxies have similar characteristics in the visible region of the spectrum, in the ultraviolet region their characteristics turned out to be very dissimilar. Many of them are characterized by abundant ultraviolet radiation, which is possibly related to the age and activity of these galaxies. A study of these galaxies may provide a key to an understanding of physical processes in the activity of galactic nuclei, since the former cannot be considered simply as clusters of a huge number of stars. Intense emission lines which were detected in the spectra of some galaxies indicate the existence of vast nebulae in them.

The birth of new branches of space astrophysics and astronomy aids science in better understanding the enormous diversity and dissimilarity of celestial bodies and processes which have occurred in the Universe. This is strikingly confirmed by the successful research carried out by the Soviet 'Astron' satellite-laboratory.

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MEETING OF INTERNATIONAL COMMITTEE PLANNING 'VEGA' PROJECT

Tashkent PRAVDA VOSTOKA in Russian 10 Apr 84 p 3

[Text] Prague. A meeting of the International Technical Commission which has taken place here was devoted to questions of the preparation of the unique international space project "Venera--Galley" ("Vega"). This project calls for a flight of research spacecraft towards Venus and a rendezvous with Halley's comet. Bulgaria, Hungary, the German Democratic Republic, the Polish People's Republic, the USSR, the Czechoslovak Socialist Republic, Austria, France and the Federal Republic of Germany (FRG) are taking part in the project. The USSR Academy of Sciences' Institute of Space Research is the coordinator of this work.

The commission's meeting in Prague demonstrated that scientists and scientific organizations of all of the countries which are participating in the project are showing a genuine commitment to the obligations they have assumed for building instruments and conducting studies of space. All of them are working on a specific scientific program. For example, scientists of France and their colleagues from Hungary, Bulgaria and the USSR have developed a three-channel spectroscope for determining the comet's composition; Austrian specialists will measure its magnetic field, and Hungarian specialists will provide support for optical experiments. Their color and black-and-white television cameras will transmit pictures of the comet's nucleus, gaseous formations and other details to Earth. Scientists of the FRG are cooperating with countries of the "Intercosmos" program for the first time. Doctor A. Richter announced that instruments for studying interactions between particles of the comet and the solar wind are being built in laboratories of the Max Planck Institute.

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NEW ASTROPHYSICAL OBSERVATORY NEAR ALMA-ATA

Moscow IZVESTIYA in Russian 30 Mar 84 p 1

[Article by M. Bayzhanov, correspondent (Alma-Ata)]

[Excerpt] A giant astrophysical complex is being created in the Zailiyskiy Ala-Tau Mountains, near Alma-Ata. This complex's observatory will be located at the highest elevation of any in the country--2,750 meters above sea level.

Tuken Bigaliyevich Omarov, a corresponding member of the Kazakh Academy of Sciences and director of the academy's Astrophysics Institute, related:

"The new observatory is located on the Assy-Turgen' Plateau, where the atmosphere's optical properties are auspicious for the scientific investigation of outer space. This structure's architecture is original--it is a tower which, together with its foundation, rises to a height of more than 40 meters and resembles a fantastic interplanetary spaceship. An effective lidar system for monitoring the Earth's atmosphere has been created here on the basis of a telescope manufactured in the German Democratic Republic.

"But the main things are still to come. Preparatory work for installing a unique, Soviet-made 1.5-meter telescope is now in progress at the observatory site. We accepted this instrument not long ago at the Leningrad Optical-Mechanical Association. The AZT-20, as this apparatus is called, weighs more than 60 tons. We think that the 'mighty' eye of the big Alma-Ata telescope will be aimed at remote space before the end of this year.

"Our telescope possesses an excellent optical system and has a number of other advantages, too. Instruments of its type that were built earlier were narrowly specialized. It is easy to reset this one and equip it with various astrophysical instruments. The AZT-20 incorporates still another innovation: it is controlled by a computer and can automatically record and interpret data that are obtained.

"We face the task of mastering one of the country's largest telescopes--the ZTK-2.6--in the more distant future. It has already been ordered and also is being manufactured in Leningrad."

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HYPOKINESIA EXPERIMENT STUDIES EFFECTS OF WEIGHTLESSNESS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 24 Mar 84 p 4

[Article by G. Lomanov, correspondent]

[Abstract] The article reports on the methods and objectives of a hypokinesia experiment which was in its 96th day at the USSR Ministry of Public Health's Institute of Medical-Biological Problems.

Professor L. I. Kakurin explained that this experiment is aimed at studying metabolic and other changes which can occur in the human organism during prolonged space missions, as a result of weightlessness. Hypokinesia produces similar changes on Earth, where they can be studied far more comprehensively than on board an orbiting station. In the course of the experiment, which was begun in December of 1983 and was scheduled to last four months, mineral metabolism and the condition of the osteomuscular system are being studied by such methods as neutron activation analysis and ultrasonic probing. One of the experiment's goals is to determine more precisely the circumstances under which imbalances of metabolism occur in conditions of weightlessness and hypokinesia, according to Doctor of Medical Sciences Anatoliy Ivanovich Grigor'yev, deputy director of the institute and scientific director of the program. The scientists are also investigating the potential effectiveness of preventive measures which have been proposed for minimizing losses of mineral substances in these conditions.

The subjects of the experiment are 15 men in good health. Their ages range from 24 to 41. They must lie in bed for the entire 120 days of the experiment. The heads of the subjects are slightly lower than the feet, for the purpose of producing a rush of blood to the head similar to that which is experienced in zero gravity. The subjects are divided into three groups of four members each, plus a three-member control group whose regimen consists solely of confinement to bed. The first of the four-member groups are receiving biologically active preparations which compensate for impairments of metabolism caused by prolonged inactivity. The second group does special physical exercises, while the third group's program combines physical exercise with preventive medications. The subjects perform these exercises regularly while lying on a couch which is equipped with pedals to turn and pull-type exercise devices that exert the muscles. This complex was developed at the institute and reportedly is being tested with a view to its

possible regular use by cosmonauts. Some of its elements are being used by cosmonauts I. Kizim, V. Solov'yev and O. At'kov in their conditioning exercises, for example. The experiment subjects' diet consists of standard food rations similar to those of cosmonauts in orbit. The subjects' physical condition and emotional state are tested and evaluated at regular intervals.

Grigor'yev mentioned that the experiment is one of a series of related studies which are being conducted by specialists of the USSR, the German Democratic Republic, Czechoslovakia and France. The Central Institute of Traumatology and Orthopedics, the All-Union Cardiology Center and the Scientific Research Institute of Medical Radiology are among the Soviet institutions which are taking part in this research.

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RESEARCHERS SPEND FIVE MONTHS IN 'BIOS-3' CLOSED-CYCLE HABITAT

Moscow TRUD in Russian 10 Apr 84 p 4

[Article by V. Vasil'yev (Krasnoyarsk)]

[Excerpt] Two young researchers, Nikolay Bugreyev and Sergey Alekseyev, spent five months in an experimental complex called "Bios-3" which simulates certain conditions of life on orbiting space stations. This important scientific experiment has been completed at the Krasnoyarsk Biophysics Institute of the USSR Academy of Sciences' Siberian Branch.

Although the young scientists did not leave Earth and did not experience g-loads, as real cosmonauts do, in nearly everything else their working and living conditions were almost the same as those on orbiting stations. One more important difference must be noted: in the "Bios-3", purification of the air and water was accomplished not by the custromary filters, but by terrestrial plants. Also, the complex had its own space garden. It provided food for the researchers. The experiment yielded data which make it possible to say even more confidently: spaceships and space stations with a closed organic-substance cycle are realistic.

I asked Doctor of Biological Sciences Boris Grigor'yevich Kovrov, deputy director of the institute, to tell about how the idea for the experiment originated and about its essence. He related: "Scientists of the Krasnoyarsk Physics Institute began work on controlled biosynthesis in 1961. The first Krasnoyarsk 'cosmonaut' went into 'flight' exactly 20 years ago, in the spring of 1964. That was in the 'Bios-1' unit, whose volume was only 12 cubic meters. A second modification was a little bit larger. And although those complexes were not designed for a full organic-substance cycle, even then we achieved total regeneration of water and air. Their purification was handled by single-cell chlorella algae. But making food for researchers from chlorella was very complicated and laborious. Therefore scientists decided that higher plants--grains and vegetables--were preferable. All the accumulated experience subsequently went into the improved complex 'Bios-3', whose volume is 315 cubic meters."

We walked up to one of the windows of the complex. On the other side of its glass it appeared as if it were a sunny summer day. Wheat on special tables

was forming ears. In one place the wheat resembled a wall of yellow, at another place it was just beginning to mature, and at a third there were only green sprouts of seedlings.

"This is a phytotron, one of three 'gardens' in the complex," Kovrov explained. "The total planting area in 'Bios' is about 60 square meters, which is quite enough to provide oxygen for four or five persons. Look at the wheat on that table. Its stalk is relatively short. This variety was developed at our institute by Doctor of Biological Sciences G. Lisovskiy. Ideal conditions for plant growth have been created in the phytotron. Although our wheat may look modest, it has a yield which calculated in terms of per-hectare yield would amount to 100-130 centners. Moreover, it gives six harvests a year. And for everyday vegetables, of which we selected more than 10 types desired by the researchers, we increased the yield by 5-8 times without losing taste qualities."

The "Bios-3" has dozens of automatic systems and hundreds of clever instruments. Most of them were developed at the institute. For example, the experiment tested a new, simpler and more reliable system for utilization of waste products, as well as original agrotechnology and effective and economical illumination of the phytotrons (electric power is the only thing that is furnished from the outside).

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PRAVDA CITES ADVANTAGES OF PROJECT FOR ORBITING SOLAR REFLECTORS

Moscow PRAVDA in Russian 9 Apr 84 p 7

[Article by Zh. Alferov, academician and Deputy Chairman of the Scientific Council of the USSR Academy of Sciences on the Complex Problem of "Investigation of New Ways of Utilizing Solar Energy" and V. Kantor, Candidate of Technical Sciences: "The Sun Shines at Night--A Very Realistic Fantasy"]

[Text] As a rule, fantasy leads us into the future and anticipates progress of which we can now only dream. The scientific and technical revolution has created the preconditions for the most fantastic achievements. It is only necessary to be able to perceive them. And the very real bases for what may appear to be the most fantastic projects can be seen today. We propose to speak of them in our new column.

Imagine that a satellite in orbit around the Earth is carrying a reflector which directs sunlight back towards our planet. A "spot" of this kind could light up one or several large areas in different time zones.

The idea of creating space reflectors was first put forward by the German, Oberth, as far back as 1929. The idea was further developed in studies by the American scientist, Eric Kraft. Today we are very close to practical realizations of these apparently fantastic projects.

But first of all, why are artificial moons of this type necessary?

The fact is that a whole series of very useful economic applications can be found for them. The use of the satellite reflectors so as to extend the daylight period in large cities by several hours would supply high-quality (shadowless) lighting for streets, transport lines and construction sites and turns out to be economically profitable. For example, the expenditure for lighting five cities like Moscow from space could be paid for by the electric energy savings in 4-5 years. And the same system of satellite reflectors can be switched to another group of cities practically without additional capital expenditure.

There is still another possibility. Localities can be lighted when night work is to be organized. For example, these may be very large construction sites in high latitudes or agricultural areas during sowing and harvesting campaigns.

The effects of variations in the duration and spectra of lighting on agricultural yields have been studied for a long time in our country. There is reason to suppose that the use of certain spectral ranges in the lighting of fields leads to increased plant growth intensity and can play an active role in the struggle against short-term night frosts. This can also be done by satellite reflectors. Continuing the list of possible applications, we will mention only the possibility of lighting areas where large-scale earthquakes and other natural disasters have occurred where rescue operations are being carried out.

But what are the available technical possibilities for carrying out such projects? The main difficulty here is linked to the fact that, firstly, in order to obtain practical results, a light reflecting surface with an area of tens of hectares must be put in orbit; and, secondly, that the profitability of such systems falls rapidly with the increase in the satellite mass to be orbited. Therefore, it is necessary to construct very lightweight units which do not require complex assembly work in orbit. At the same time, the lightening of the units leads to a reduction in rigidity and thus in the precision with which the light flux can be pointed. An effective control system can compensate for these losses.

Researchers have already worked out the general features of the profitability configuration for future orbital lighting systems. It seems to be possible to assemble them from groups of individual autonomous satellite reflectors distributed in suitable orbits. Each of these will resemble an ordinary folded umbrella which will automatically open after being put into orbit. The light reflecting surface in these satellites will probably consist of a metallized polymer film. The light flux will be oriented by a distributed control system which will compensate for oscillations in the unit.

Experimental models of space reflectors could be constructed in the next few decades through an appropriate organization of scientific research and experimental construction work together with the creation of units and the study of the principles of space reflector control. The USSR Academy of Sciences and several ministries consider it advisable to begin this work at the present time. This work deserves to attract considerable university scientific staff especially as a start has already been made.

For example, in the Moscow Aviation Institute imeni Ordzhonikidze, a design has been created for an orbital experiment with a satellite reflector with a mass of not more than 200 kg and an effective surface of 110 square meters. An experiment of this kind is intended, in the first phase, to test the technical solutions which are basic to the construction of the future space reflector. The illumination at the ground receptor with a diameter of around 10 km should be seven times more intense than at midnight (around 1.5 lux).

Experimental ground units have already been created at the Institute by a group of workers and students which demonstrate the processes of reflector opening and control of the shape of the satellite reflector. It is desirable that the USSR State Committee for Science and Technology and the USSR Ministry of Higher Education make a decision as to the creation of the research base.

It is also essential to organize the study of the ecological consequences of the use of space reflectors and draw up recommendations for the rational use of such systems so as to produce beneficial environmental results.

The Sun is the most powerful energy source and it should serve the population even more effectively.

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SPACE TRANSPORTATION SYSTEMS OF THE FUTURE

Moscow KOSMICHESKIY TRANSPORT BUDUSHCHEGO (NOVOYE V ZHIZNI, NAUKE, TEKHNIKE: SERIYA "KOSMONAVTIKA, ASTRONOMIYA") in Russian No 11, Nov 83 pp 15-59

[Extract of book "Space Transport of the Future" from series "Cosmonautics and Astronomy" by Sergey Dmitriyevich Grishin and Sergey Vasil'yevich Chekalin, Izdatel'stvo "Znaniye", 28,190 copies, 64 pages]

[Text] Methods for Improving Space Transport Systems

Modern Space Transport Systems: Achievements and Shortcomings

Before we begin predicting the development of space transport systems in the future, we will examine the achievements and shortcomings of existing means of transport--traditional launch vehicles and outer-space booster stages. In the first years of space exploration, only the USSR and the United States possessed the necessary space-rocket technology. As scientific and technical reserves and the industrial capacities for them accumulated, France (1965), Japan and China (both in 1970), Great Britain (1971) and Italy (1980) joined in.

Among the launch vehicles developed in the USSR which are noted for their high thrust-to-weight ratios and reliability, we must note the Vostok, Cosmos and Proton and the launch vehicle for the Soyuz spacecraft. The United States also developed a system of launch vehicles, the majority of which were modifications of military ballistic missiles of the Atlas, Thor and Titan types, which were used as first stages. The special Saturn series of superpowerful launch vehicles were also developed.

The variety of types of launch vehicles created with payloads from a few hundred kilograms to more than 100 tons as well as the experience gained in their operation make it possible to trace the progress that has been made in achieving and improving launch-vehicle performance and, simultaneously, to trace the shortcomings inherent in such means of transport. During the period of development of space transport systems, their mass-to-payload ratio has improved considerably. Although the first high-altitude meteorological rockets expended several hundred kilograms of fuel for each kilogram of payload, the Scout rocket of the 1950's used only 115 kg of solid fuel per kilogram of payload carried, while the Saturn-5 launch vehicle has reduced the fuel expenditure to 20 kg per kilogram of payload.

The improvement in launch-vehicle performance was made possible by the transition to more efficient rocket motors and reductions in the structural weight of the rocket stages. The liquid-fuel rocket motor of the V-2 rocket, for example, used an oxygen-alcohol fuel mixture to develop a specific impulse (that is, the ratio of the thrust to the total mass of fuel consumed per unit of time) of 280 s, while a modern liquid-fuel rocket operating on an oxygen-hydrogen fuel mixture in a vacuum provides a specific impulse of up to 455 s.

The mass of the V-2 rocket's structure, including the body, fuel tanks, pumps, rocket motors and other parts comprised about 25% of the total mass of the rocket. Achievements in the area of creating lightweight rocket structures made it possible to bring the present relative mass of a rocket stage's structure down to 7.6%. The cost indicators have been considerably improved as well. In the period from 1958 to 1978, for example, the cost of just launching a payload to a low artificial-satellite orbit was reduced in the United States from 80,000 dollars to 5,000 dollars per kilogram.

Nevertheless, the performance characteristics and operational conditions of launch vehicles are still far from being perfected. The high cost of both the means used to place a payload into orbit and the payload itself as well as the necessity for enlisting great industrial capacities for their manufacture continue to be factors which impede the broad utilization of space-rocket technology. Moreover, in order to operate modern launch vehicles, it is necessary to have cleared zones, that is, areas of the ocean's surface free from navigation or unused regions of land where the depleted stages may fall. With the passage of time, this becomes more and more difficult because of man's intensively developing agricultural activity which occupies more and more new territories.

Still another problem is the cluttering of near-earth space with the spent upper stages of launch vehicles and space craft which have completed their term of active service. At the present time, there are in space several thousand such objects. Their numbers are growing and the increasing cluttering of space is beginning to cause worry. We are protected from the falling remnants of such objects in space by the dense layer of the atmosphere in which they burn up. They are becoming dangerous for aviation, however, particularly for supersonic jet transport aircraft flying at high altitudes (up to 18 km) where the kinetic energy of the falling fragments has not yet had a chance to dissipate.

Special observations of falling space objects are conducted. According to a UN resolution, the states which launch artificial satellites are obligated to bear financial responsibility for possible damage and destruction of various objects on earth and in the air caused by collisions with parts of rockets and satellites falling from space. It is likely that an international agreement will be approved in the future which will obligate those states which launch spacecraft to free the orbits suitable for flights of piloted space stations from spent rocket stages and other objects.

It is assumed that these problems can be partially solved by returning rocket stages and spacecraft to earth.

The Concept of Reusability and Questions of Profitability

The idea of repeated usage of rocket launch systems is not new. It was expressed in the works of such founders of astronautics as K. E. Tsiolkovskiy, F. A. Tsander and Yu. V. Kondratyuk, as well as in the works of famous foreign experts such as H. Obert, R. Goddard and others. The introduction of reusability, however, is associated with additional expenditures of power and mass and with the solution of a number of technical problems. These are, in particular, the creation of rocket motors with long service life and reusable heat shielding for the upper stages. These were essentially difficult goals to realize in the initial stages of space-rocket technology.

The questions of reusability started to come under serious discussion in technical literature starting in the 1960's. Numerous technically and economically sound foreign designs for reusable space transport systems for placing objects into orbit showed that the effectiveness of such systems essentially depends upon their technical level of development and the operational conditions. In this case, their application can have an impact only if there is extensive use of the principle of reusability for the payload as well. The complexity of the concept of reusability and shortcomings in the economic grounds upon which this concept is based at the present stage were confirmed during the realization of the American design for the Space Shuttle reusable space transport (MTKK).

The attempt to find a combined solution to the problem (reduce the cost per launch and insure the feasibility of returning the payload for repeat usage) led to the necessity for including in the space transport system a piloted spacecraft built according to aircraft configuration. The reusable space transport is launched into orbit with the help of two solid-fuel boosters in the first stage and a hydrogen-oxygen second stage, with the main motor unit of the second stage being located in the orbital craft (or the orbital stage).

After they cease operation, the first-stage boosters separate from the second stage, complete a passive flight along a ballistic trajectory and fall into the ocean on parachutes. They are then towed to shore and delivered to the servicing base so that they can be reconditioned and reused (up to 20 times). The fuel cell of the second stage separates from the spacecraft not long after the latter achieves orbit and falls into the ocean, breaking up as it enters the dense layers of the atmosphere. After the orbital spacecraft leaves orbit and decelerates in the atmosphere, it lands at a special airfield like an airplane.

It is proposed that a single reusable space transport be used for no less than 100 flights, with replacement of individual elements during its operational life (motors and heat-shield tiles). Such a space transport system with a launch mass of 2,000 t provides for the launching into near-earth orbit and the return from orbit to earth of payloads of 29.5 and 14.5 t, respectively, in the cargo compartment of the orbital craft (18.3 m long and 4.6 m in diameter).

The development of the reusable space transport encountered a number of difficulties of a technical and technological nature. One of these was associated with the creation of reusable tile heat-shielding for the orbital craft. It

was necessary to cover the body of the orbital craft (and it does have a rather complex form) with several tens of thousands of heat-shielding tiles of various shapes and thicknesses (the temperature of the craft's heating at various points as it descends and decelerates in the dense layers of the atmosphere changes from several hundred to 1,500°C). Another complication consisted of the creation and development of a highly reliable oxygen-hydrogen sustainer engine for the second stage with increased service life (designed for 55 flights).

Design development was conducted for 10 years, while the first test flight was delayed for three years and took place in April 1981. A total of eight flights were carried out in the two and a half years since the first flight. The initially planned pace of launches during official operations provided for 60 launches per year.

The cost of launching the payload into orbit did not decrease considerably, and this was the main thing the developers of the reusable space transport had hoped for. The cost of launching the craft as stated at the beginning of the development was 10.5 million dollars, and this increased several times over during the following decade. Meanwhile, the Scout, Delta and Atlas-Centaur expendable launch vehicles which the new space transport system had been proposed to replace remained in operation. The cost of launching the large passive mass of the orbital craft in addition to the payload increased considerably the launch mass of the space transport system in comparison with launch vehicles having the same payload capacity. According to the estimates of American specialists, the Space Shuttle reusable space transport as a launch system is inferior to new (that is, developed on the same technological level) expendable launch systems with respect to overall transportation costs.

It had been planned that the main saving in resources from the application of the reusable space transport was to be derived due to the reduction in the cost of the payload. This so-called "payload impact" was associated with the feasibility of carrying out preventive maintenance, repair, restoration and other operations involved in servicing the payload, either in orbit or upon return to earth. This would increase the payload's active service life and reduce the costs of the space program on the whole. In this case, plans had been made to make extensive use of modular principles of construction with the employment of standardized systems and units in the development of payloads.

The transition to a new, serviceable payload, however, is also associated with additional expenditures of time and resources. In this case, due to the limited manueverability of a heavy orbital craft in flight, only those objects located in low near-earth orbits can be serviced. In order to service payloads in higher orbits (in the future, according to the opinion of a number of specialists, up to 50% of all payloads will be located in geostationary orbits), it will be necessary to develop reusable interorbital tugs.

Thus, the creation of an economical reusable space transport system at this stage is a complex task, and it is now difficult to judge how effective the Space Shuttle reusable space transport will prove to be in this respect. One can only note that the very optimistic statements (very much like advertisements) regarding the profitability and universal nature of the application of

reusable space transport that occurred at the beginning of its development have been replaced by more sober and moderate assessments of the scope of its application. Although there previously had been talk of a program of 725 flights of the Space Shuttle craft planned for 12 years, for example, this number was subsequently reduced several times. At the present time, only 311 flights of the reusable space transport are planned in the period to 1994.

The configuration selected for the American reusable space transport is a compromise not only in the plan for the introduction of reusability. The application of two solid-fuel boosters as a first stage contributes to increasing the reliability of the system and the safety of the crew, but at the same time leads to the danger of fouling the atmosphere with the products of solid-fuel combustion, including ammonia perchlorate, butadiene and admixtures of aluminum. From the moment the reusable space transport is launched until the time it reaches a height of approximately 40 km (cessation of booster function), several hundred tons of combustion products are released into the surrounding space, including such toxic components as particulate aluminum oxide, carbon monoxide, gaseous hydrogen chloride, etc. The harmful effects of these combustion products can consist of toxic pollution of the cloud cover, the fall of acid rain and unforecasted weather changes.

There exists another danger of this type--the destruction of the stratospheric ozone layer from the action of chloride compounds, that is, the formation of so-called "windows" in the ozone layer. As is well known, this layer protects all living creatures on the earth from lethal ultraviolet rays given off by the sun.

One must say, of course, that all these shortcomings and the compromise nature of the American space transport system based on the Space Shuttle reusable space transport were predetermined to a great degree by the militaristic essence of the given program. Since a considerable number of reusable space transport launches are now planned for the purposes of the U.S. Department of Defense, the developers of the American reusable spacecraft have been pressured by the Pentagon, which is trying to get this space transport system into operation as soon as possible, even at the expense of design imperfections.

In any case, research into methods of improving space transport systems continues at the present time.

Improving Rocket Motors and the Design and Control Systems for a Space Transport System

Over the previous period of development of space-rocket technology, a high level of performance has been achieved for liquid-fuel rocket motors. Using the example of the motor in the second stage of the Space Shuttle reusable space transport, one may note that the specific impulse of the oxygen-hydrogen sustainer engines in a vacuum is 455 s. The thrust of these motors can be regulated over a broad range, and the motors are designed to have a total service life numbered in dozens of flights. Considerable success has been achieved in the area of control systems and in diagnosing engine operation. This has increased considerably the reliability and safety of their operation. Onboard computers have come into use to control engine operation.

Together with the futher improvement in oxygen-hydrogen liquid-fuel rocket motor performance, foreign rocket-motor builders have recently begun to devote great attention to investigating the possibilities of twin-fuel propulsion systems. It is proposed that two types of fuel--hydrocarbon and hydrogen--be used in a twin-fuel propulsion system with a single oxidizer (oxygen). This will make it possible to realize jointly the advantages of a fuel with a hydrocarbon propellant (high density and a low mass for the propulsion system) and the advantages of a fuel with hydrogen as a propellant (high specific impulse). The most efficient is the utilization of the same engine for both fuels, in which it is proposed that there be a sequential burn-off of fuel (hydrocarbon first, then hydrogen).

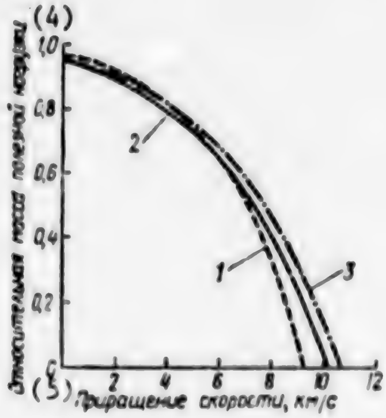

Fig. 1. Dependence of the relative mass of the payload on the required increase in velocity for twin-fuel and traditional propulsion units: 1 - Hydrocarbon fuel only; 2 - Hydrogen only; 3 - Sequential burn-off of fuel through a common engine; 4 - Relative mass of the payload; 5 - Increase in velocity, km/s

Fig. 1 presents the dependence of the relative mass of the payload upon the required increase in velocity for twin-fuel and traditional propulsion systems.

Thanks to the lower relative mass of a propulsion system whose fuel has a hydrocarbon propellant (1), such a fuel is more advantageous when there are small increases in velocity. As the necessary incremental gains in velocity increase, however, a hydrogen fuel (2) proves to be more efficient, thanks to the significantly greater specific impulse. The slope of curves 1 and 2 changes in favor of hydrogen fuel, starting with velocity increments that exceed approximately 2 km/s.

The dependences are presented without consideration of the velocity losses due to the overcoming of gravitational forces (only the ideal velocity is calculated). It must be noted that, due to the small specific impulse, the burn-off of fuel with a hydrocarbon propellant requires a considerable expenditure of fuel components in the initial flight phase. All other conditions being equal, this entails an increase in the craft's acceleration and, subsequently, a reduction in the velocity losses due to the overcoming of gravitational forces. This is an additional argument in favor of a twin-fuel propulsion system.

Another reserve for improving the performance of future space transport systems is their further refinement with respect to structural mass. Potential possibilities for reducing the structural mass are determined by the utilization of new materials and the introduction of various designs, as well as by improving methods of creating designs. It is expected that glued joints will be more extensively utilized (in an effort to reduce the mass of fasteners). Together with the development of new metallic alloys with improved strength and operational indicators, composite materials based on polymer and metallic binding components, reinforced with high-strength fibers of boron, graphite, monocrystalline fibers, etc., will become more popular.

According to the assessments of foreign specialists, the advantages of structures made from advanced composite materials over structures in aircraft and spacecraft made from fiberglass and aluminum are particularly manifest when they are used in cases when a low coefficient of thermal expansion, lightness of construction, high rigidity of their spatial structure and thermal insulation are required. In order to make extensive application of composite materials in space technology, it is necessary to thoroughly study means of improving the production processes involved in their manufacture and means of reducing their costs. Moreover, a careful analysis of the influence of the effects of loading conditions and the environment on the service-life characteristics is likewise necessary. In accordance with these assessments, parts made of composite materials can be 25 to 30% lighter than those made of aluminum.

There are also potentials for improving heat-shielding systems. The reusable ceramic shielding used on the American space transport endures a sufficiently high heating temperature, yet has a number of inherent shortcomings: brittleness, a tendency to absorb moisture and the labor-intensive nature of its manufacture and servicing. In this respect, metal heat-shielding systems with a limited utilization of active cooling are worthy of attention. In such systems, the heat is drawn off from highly heated surface sections by the circulation of the coolant (from the leading edges of the wing of the orbital craft, for example) and is transferred either to special radiators which radiate the heat into the environment or to surface sections with relatively low temperatures which then fulfil the role of radiators.

A reduction in mass can be achieved in the transition to new designs for fuel cells that combine the properties of a load-bearing structure and a thermal insulator for cryogenic fuels. The storage of cryogenic components (liquid hydrogen and liquid oxygen, for example) onboard a space transport system is only possible with the creation of special types of thermal-insulating structures. In this case, particular difficulties arise from the use of liquid hydrogen as a consequence of its low boiling point (20°K) and low density (71 kg/m^3). This leads to the creation of large-volume tanks with large surface areas. Damage to the insulation of the fuel cell leads to the tank being penetrated by air and moisture. The air condenses and freezes, forming a vacuum at the point of penetration. New batches of air penetrate and in the end form a heat bridge, that is, a bridge between the cold wall of the fuel cell and the heated environment. The strong influx of heat into the cell leads to intensive boiling of the fuel components.

One of the variants of an advanced structure that unites the functions of heat-shielding and thermal insulation is depicted in fig. 2. It is expected that such structures will have a lower specific mass, will be simpler and easier to manufacture and will resist acoustic loading well. Their utilization, however, must be preceded by wide-ranging scientific research and design-experimental studies in a number of directions: an evaluation of the compatibility of the structural materials with cryogenic components and their behavior under low-temperature conditions with repeated loadings; the development of structures with a minimum coefficient of heat conductivity; the development of methods for reducing temperature stresses; the manufacture of advanced structural prototypes as well as full-scale models that have been thoroughly tested.

The control system plays a large role in optimizing the design and improving advanced space transport systems. Active control systems have recently come into use recently together with the traditional control systems. The application of active control systems makes it possible to reduce wind and aerodynamic loading during flight, to reduce mass, to improve flight performance and controllability and to expand the range of flight conditions for the items being designed (by developing so-called adaptive flight programs onboard). The development of active control systems has become possible through the application of electrical (remote) flight-control systems, since they make it possible to make extensive use of the onboard electronic computers (BEVM).

The range of problems solved by control systems continues to expand. For advanced space transport systems, the utilization of control systems is planned not only for insuring flights along trajectories that have been optimized with respect to the energy required to maintain them and to reduce loads during flight, but also to automate prelaunch preparations, the launch itself and the planning of flight programs (including maneuvering operations, approaches or dockings in space and the servicing of payloads). In connection with this, the necessary memory capacity and speed of operation of onboard electronic computers are increasing (table 1).

Generally speaking, the development of onboard lectronic computers at the present stage includes a modular principle of construction based on the utilization of standard units; a multiprocessing structure; the utilization of modules of specific functional designation; an expanded system of commands; microprogramming (flexible) control; insensitivity to failures due to the utilization of backup equipment and the capacity to reconstruct the computer's logic structure in the event of failure; and the extensive application of large integrated circuits.

Finally, we must mention the improvement of the very methods used to optimize designs that have been developed on the basis of mathematical programming and the application of high-speed computer technology. In the future, these methods will consider the requirements of reliability, the stochastic nature of external influences and the nonstationary nature of these limitations. Perfected calculation methods and a better understanding of the physics of phenomena will make it possible to reduce the reserves of strength, stability, controllability, etc., in designing advanced space transport systems and will thus contribute to facilitating their design.

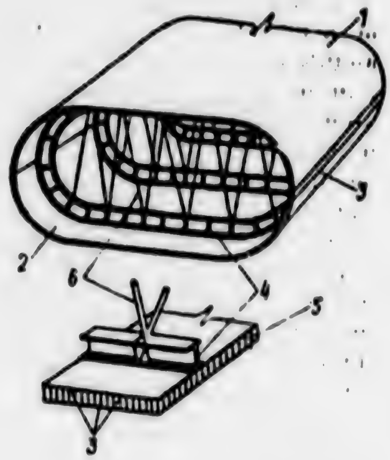

Fig. 2. One of the variants of an advanced structure uniting the functions of a load-bearing structure, a heat-shield and thermal insulation: 1 - Skin of the upper surface made from titanium alloy; 2 - Skin of the lower surface made from a special heat-resistant alloy; 3 - Compensating slots for temperature deformations; 4 - Frame; 5 - Honeycomb; 6 - Struts

Table 1. Characteristics of Advanced Spaceborne Onboard Electronic Computers (according to estimates of foreign specialists)

Characteristics	1980	1985	1990
Productivity of a single processor, millions of operations per second	2.5	6.3	14.4
Capacity of memory unit, bits per crystal	500K	20M	800M

Requirements for Space Transport Systems

The prospects for the development of near-earth space and the problems associated with the operation of modern equipment for launching spacecraft makes it possible to formulate general requirements for the space transport system of the future.

It has been suggested that the deployment of large-scale structures in space will be carried out using a great number of identical elements, assemblies and parts, the manufacture of which will be possible immediately onboard an orbital space station using semifinished materials brought up from earth (rolled sheet metal wound on a spool, for example). The transportation of raw materials and finished goods of space production will be possible in containers using sufficiently dense packing. For this reason, the volume and mass of the payload modules are not limiting factors for advanced space transport systems.

More important from the point of view of the efficiency and profitability of carrying out large-scale long-range tasks in space (the deployment of satellite solar power stations, heavy orbital industrial complexes, etc.) are the requirements that space transport systems have high productivity (the volume of annual freight traffic) and relatively low specific expenditures for transportation. For example, the deployment of a system of standard satellite solar power stations with an output of 5-10 GW, the average annual volume of freight traffic to low near-earth orbit will change by hundreds of thousands of tons, and the necessary specific cost of transportation, based on the profitability of satellite solar power stations, should be reduced by more than a factor of ten, according to the estimates of experts.

We must also note the advisability of dividing space transport systems into purely freight and passenger systems (it being the case that the former systems will comprise the major portion of the freight traffic into space). The elimination of limitations imposed by the presence of man onboard will make it possible to expand the search for more efficient schemes for launching payloads into artificial earth-satellite orbits. At the same time, the passenger space transport systems designed to carry a limited number of specialists into space basically to carry out assembly operations, control and monitoring functions and repair and preventive-maintenance operations can be realized on the basis of traditional launch means as well. In this direction, we do not exclude the search for more efficient and profitable space transport systems, for example, in the organization of space colonies, but these means will differ considerably from advanced space freight-transport systems due to comfort and safety considerations.

Finally, the requirement that freight be delivered to stable near-earth orbits with a minimum of damage of an ecological nature remains unchanged for all advanced space transport systems. The application of advanced space transport systems on a broad scale must not pollute the earth's atmosphere with harmful combustion products, must not exceed permissible standards for acoustic loading and must not jettison in flight nor leave in orbit individual structural elements.

Transportation Means in Industrial Space

The Potentialities of Advanced Space Transport Systems with Liquid-Fuel Rocket Motors

In terms of the general requirements for future space transport systems, we will first of all examine the potentialities of advanced space transport systems with liquid-fuel rocket motors. Propulsion systems based on liquid-fuel rocket motors have long been successfully utilized to study and explore space. It would perhaps not be an exaggeration to say that in the minds of the majority of nonspecialists, liquid-fuel rocket motors are just about the only means of creating thrust in space. This, however, is far from true. Despite the possiblity for perfecting them, transport systems using liquid-fuel rocket motors are limited with respect to their output. This can be determined easily by turning to Tsiolkovskiy's famous formula determining a rocket's increase in velocity ΔV in a vacuum in the absence of gravitational forces: $\Delta V = W \ln Z$ (where W is the velocity at which the working medium is discharged and Z is the ratio of the

initial mass of the spacecraft to the final mass, when the weight of the onboard reserve of the working medium or a portion thereof has been expended; this is the so-called Tsiolkovskiy number).

The maximum value for the velocity of discharge of the working medium for a liquid-fuel rocket motor is about 5 km/s. The increase in the rocket's velocity also depends upon the ratio of the intial mass to the final mass. In modern launch vehicles with liquid-fuel rocket motors, the mass of the fuel can come to 85% of the launch mass. A simple calculation shows that for a single-stage vehicle with a liquid-fuel rocket motor, the increase in velocity does not exceed 9.3 km/s, that is, the limited power potential of such a vehicle insures its launch to only a low near-earth orbit. Naturally, the utilization of the multistage principle expands these potentials, but this makes space flight more complicated and expensive, and, as we stated earlier, leads to a cluttering of space with spent stages in the event that those who effected the launch declined to return them.

Thus, the desire to simplify and reduce the costs of space transport systems with liquid-fuel rocket motors to the maximum degree possible in the future, that is, to make the transition to an ideal, single-stage scheme, conflicts with the power potentialities of such systems for which multistage construction is necessary from the standpoint of increasing the mass ratio or expanding the area of application. In this case, the effect from the design improvements of space transport systems expected in the future, as a rule, is eliminated by the additional expenditure of mass for insuring the return and repeat utilization of the space transport system, which is dictated by economic or ecological considerations. The numerous designs for advanced space transport systems with liquid-fuel rocket motors now being published in the foreign press are an attempt to find such a compromise design.

Basically, these are one- or two-stage vehicles of winged or ballistic configuration (fig. 3a, b). The winged configuration is being examined for piloted space transport systems with relatively small payloads (characteristic of this system are comfortable conditions for return--a launch with small G-loads and an airplane landing). The ballistic configuration is being examined for heavy, pilotless space transport systems (it insures a high mass ratio, that is, the ratio of the mass of the payload to the launch mass of the space transport system). On the whole, however, the mass ratio of advanced space transport systems with liquid-fuel rocket motors is no higher than expendable launch vehicles and amounts to only a few percent of the launch mass, that is, when launching payload modules of several dozen tons to several hundreds of tons, the launch mass of such space transport systems amounts to thousands of tons.

It must be noted that the specific indicators for advanced space transport systems with liquid-fuel rocket motors (with respect to the mass ratio and the cost of the launch) improve as their scale increases. Due to the limitations brought about by existing standards for acoustic loading which rises sharply with an increase in the launch mass of the space transport system, however, the maximum value of the payload launched cannot exceed 500 t.

In an effort to increase the output performance of space transport systems with chemical rocket motors, designs are being examined for launch systems which utilize combined propulsion systems, uniting into a single unit both rocket and turbojet or ramjet engines. The expected efficiency of utilization of combined propulsion systems is explained by the fact that turbojet and ramjet engines have a specific impulse 8 to 20 times as great as liquid-fuel rocket motors (calculated on the basis of the expenditure of fuel stored onboard the vehicle). The application of more efficient, albeit heavier, propulsion units on a segment of the boost in the atmosphere (that it, the utilization of the external resources of the atmosphere, in this case, the air, as an oxidizer and a working medium) is alluring, particularly for one- and one-and-a-half-stage space transport systems. As the estimates show, the relative mass ratio with respect to the payload of such space transport systems can be increased to 7 to 8%. In this case, the type of launch can be either vertical or horizontal (fig. 3c).

Despite the potential for reducing the specific cost of orbital launches (the cost of placing 1 kg of payload into orbit) several times over, advanced space transport systems using liquid-fuel rocket motors nevertheless continue to remain sufficiently complex and formidable systems for realizing large-scale freight traffic (for deploying a satellite solar power station in geostationary orbit, for example). If one takes 250 t as the nominal value for the cargo capacity of an advanced, superheavy booster, then the creation of the first standard satellite solar power station with a mass of 40,000 t in a geostationary orbit (corresponding to 200,000 t in low near-earth orbit) using interorbital transport craft with liquid-fuel rocket motors would require 800 launches, which would expend about 5 million tons of rocket fuel. Such a program of launches is the limit for the booster. Indeed, dozens and hundreds of similar satellite solar power stations would be required to support the kind of power industry necessary on a worldwide scale. The intensive flights of superheavy space transports with liquid-fuel rocket motors together with the expenditure of hundreds of millions of tons of fuel would be accompanied by considerable thermal discharges into the atmosphere, and this would be fraught with serious ecological disturbances.

Space Transport Based on Nuclear Power

An important area in the direction of increasing the power (mass ratio) of launch vehicles is the transition to higher-efficiency rocket motors, for example, nuclear rocket motors. In this case, the number of booster launches would be reduced as well as the total expenditure of fuel needed to carry out long-range space tasks.

In a liquid-fuel rocket motor, the working medium is formed by the combustion of fuel. In this case, the composition and temperature of the combustion products and, in the final analysis, the specific impulse are determined by the properties of the fuel used. In contrast to this, the heat released in nuclear reactors is used in a nuclear rocket motor to heat the working medium. The source of energy and the working medium here are different. Hydrogen is preferred as the working medium--it possesses the highest gas constant, which, together with the temperature and degree of nozzle expansion, determines the specific impulse of the motor.

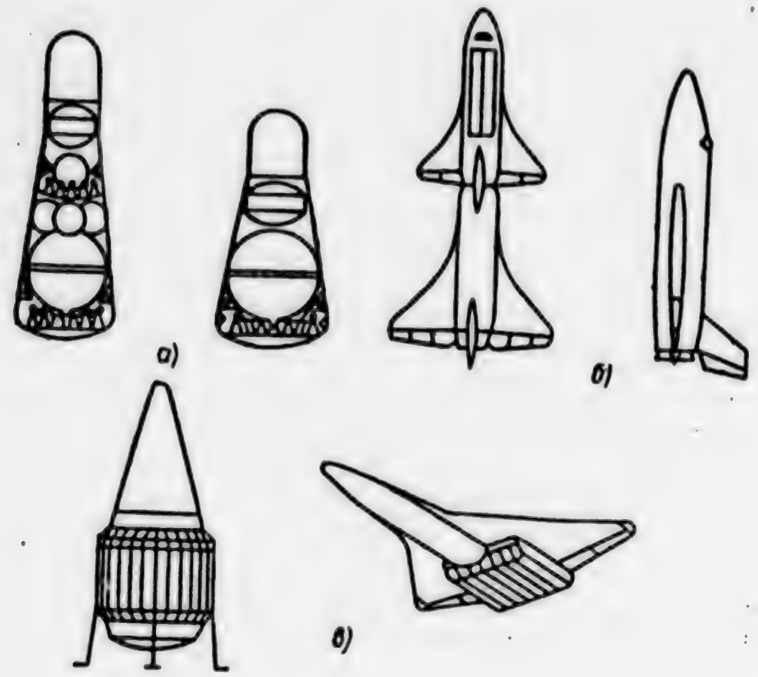

Fig. 3. Configurations of advanced one- and two-stage space transport systems using liquid-fuel rocket motors: a) ballistic; b) winged; c) with the application of ramjets

When the hydrogen is heated in a nuclear reactor, the specific impulse depends basically upon the temperature in the core. Depending upon the phase state of the substance in the core, nuclear rocket motors are divided into solid-phase, liquid-phase and gas-phase. Of the greatest interest are solid-phase nuclear rocket motors (with respect to the degree to which they have been developed and the preliminary work which has been done) and gas-phase (according to its high specific indicators). As an example of a solid-phase nuclear rocket motor, one can cite the motor developed in the United States at the beginning of the 1970's under the Nerva program (thrust of the motor--330 kN; specific impulse--825 s).

The maximum specific impulse from a solid-phase nuclear rocket motor is limited by the melting temperature of the fissionable medium and amounts to 900 s. This is twice as high as the best modern liquid-fuel rocket motors. The gains obtained from this increase in the specific impulse, however, are reduced due to the increase in the mass of a space transport system using nuclear rocket motors. This is dictated by the presence of the nuclear reactor, the radiation shielding for the crew and the payload and, finally, a massive thermally insulated tank for holding the reserve of liquid hydrogen. For liquid-fuel rocket stages using oxygen-hydrogen fuels, the ratio of the mass of the working medium to the mass of the rocket's structure lies within the range of 7:1 to 8:1, while for stages with nuclear rocket motors, this parameter is reduced to 3:1 to 5:1.

This is why, despite the preliminary work which has been done in the area of solid-phase nuclear rocket motors and the feasibility of their practical realization, great attention from the standpoint of the creation of advanced space transport systems has been aroused by gas-phase nuclear rocket motors, the specific impulse of which can reach 2,000 to 2,500 s. These nuclear rocket motors, existing at the present time only in the design stage, do not differ from solid-phase nuclear rocket motors with respect to the basic principle of operation. However, in connection with the fact that during their operation, the substance in the core of the reactor is in the gaseous state, one can raise considerably the temperature to which the working medium is heated and, consequently, the specific impulse as well. In this lies their advantage, but, correspondingly, their creation requires the solution of more complex technical problems.

At the heating temperatures of the working medium for which gas-phase nuclear rocket motors are designed, the nuclear fuel in the reactor is in the form of a plasma at a high pressure (500 to 1,000 atm), otherwise the density of the fissionable material will be too low to insure critical reactor loading. For this reason, it is necessary to create a high-strength engine structure. Another difficulty is the problem of the separation of the nuclear fuel from the heated working body in the reactor core. The most promising in this direction is the gas-phase nuclear rocket motor with magnetic confinement of the nuclear fuel. It is proposed that gas-phase nuclear rocket motors with magnetic confinement of the nuclear fuel will possess thrusts in the range from several dozen to tens of thousands of kilonewtons, insuring a sufficiently high degree of thrust for space transport systems.

The common problem in the application of space transport systems with nuclear rocket motors, however, continues to be the guarantee of radiation safety. An operating nuclear rocket motor is a powerful source of gamma and neutron radiation. Under the effects of radiation, there can occur a heating of the working body and the structure beyond maximum limits, embrittlement of metal parts and destruction of plastic parts, deterioration of the insulation on electrical cables and the failure of electronic equipment. The most important thing, however, is that there exists the danger of radiation injury to the crew (fig. 4).

The greatest radiation danger during the operation of space transport systems with nuclear rocket motors exists during the launch on the earth and the flight through the atmosphere. Under the conditions of open space, one can use a limited, so-called "shadow" shield which guarantees shielding of the crew only in the vacuum of space where there is no dispersed radiation from the air. For space transport systems launching from the earth, it is necessary to have much heavier circular shielding. There always exists the danger of radiation contamination during the operation of such space transport systems due to the radiation directed at the craft's structure, the radiation of the reactor after the nuclear rocket motor is shut down, the possible contamination of the atmosphere, etc.

For all appearances, space transport systems with nuclear rocket motors will find application outside of the earth's atmosphere--in interorbital transport operations during the delivery of heavy cargo to geostationary orbits and in freight operations along the path from near-earth orbit to the moon. Great potentials are opening up for interplanetary flights for space transport systems using nuclear rocket motors.

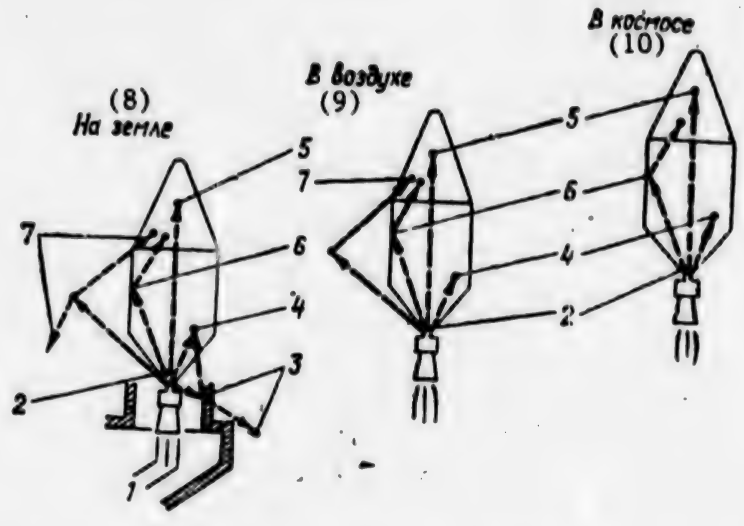

Fig. 4. Nature of radiation danger during nuclear rocket motor operation: 1 - Effect of exhaust jet; 2 - Radiation damage to structure of space transport; 3 - Irradiation of the launch apparatus; 4 - Heating of the working medium in the tank; 5 - Direct propagation of radiation into the paylaod compartment due to dispersion within the structure (6) and due to dispersion in the air (7); 8 - On the ground; 9 - In the air; 10 - In space

In examining the application of nuclear power in space transport, we must dwell in particular on the feasibility of creating thermonuclear rocket motors in the future. This is essentially a new step on the road to developing space propulsion systems. According to a preliminary estimate, a thermonuclear rocket motor with a thrust of several thousand kilonewtons is capable of achieving a specific impulse of 18,000 s, which exceeds the specific impulse of advanced liquid-fuel motors by more than a factor of 30. The relative freight-carrying capacity of space transport systems with thermonuclear rocket motors is increased dozens of times in comparison with existing systems.

Designs for space transport systems with thermonuclear rocket motors have been stimulated to a great degree by the development of thermonuclear power which has been conducted for several dozen years. These works are first of all directed at creating controllable thermonuclear reactors. These works provide for an initial heating of the reactive substance (heavy isotopes of hydrogen--deuterium and tritium) to a temperature of several million degrees. This temperature should correspond to an energy level sufficient to fuse the nuclei , as a result of which the tremendous energy of thermonuclear fusion will be liberated.

True, it must be said that the deuterium-tritium fuel which is extremely convenient to use in future industrial thermonuclear reactors may prove to be little suited to use in thermonuclear rocket motors, since during the burning of this fuel 80% of the energy comes from fast neutrons which easily leave the plasma and bring about a heating of the thermonuclear rocket motor's structure, thus limiting the magnitude of the specific impulse. It is more convenient to

use a mixture of deuterium and a light isotope of helium (only 2% of the energy will come from the neutrons). This, however, encounters another problem no less complex: in order to accomplish the desired reaction, a temperature of hundreds of millions of degrees is required.

Thus, the nuclear rocket motor is still a rather problematic unit, yet space transport systems using such motors would make it possible for man to become, in the true sense of the word, the master of the Solar System (for this reason, we will touch upon propulsion systems based on nuclear rocket motors a little later on, in the section on advanced space transport systems for interplanetary flights).

Space Transport Systems Using Electric Rocket Motors

Together with space transport systems which possess a high degree of thrust but are limited by their economy with respect to fuel expenditures (liquid-fuel and nuclear rocket motors), there exist in space rocket technology low-thrust systems utilizing electric rocket motors. The first to express the notion of the utilization of electricity to create reactive thrust was K. E. Tsiolkovskiy in 1911, while the world's first study of the design of an electric rocket motor was begun in 1929 on the suggestion and under the guidance of V. P. Glushko.

In contrast to liquid-fuel and nuclear rocket motors, the working medium (gaseous products from the combustion of a chemical fuel in the former; hydrogen that is heated as it passes through a reactor in the latter) is accelerated as it is discharged through a nozzle (where the thermal energy is converted to kinetic energy), the working medium in an electric rocket motor receives its acceleration by means of electric power. In this case, the working medium and the source of power are different. The specific impulse that can be achieved exceeds by an order of magnitude or more the specific impulse from a liquid-fuel or a nuclear rocket motor owing to the great amount of energy delivered to a small mass of working substance in the electric rocket motor.

The working medium in an electric rocket motor is plasma, that is, an ionized gas conducting an electric current. The plasma is accelerated by electrodynamic forces which arise as a result of the interaction of an electrical current passing through the plasma and a magnetic field created by an external source or by a current flowing through an accelerator. In addition to the plasma accelerator, an electric rocket motor includes a system for delivering the working medium, elements of a system for switching and transforming the current, a regulating system, etc.

An electric rocket motor propulsion system includes, besides the electric rocket motor itself, a power source (a nuclear reactor or a solar battery can be used for this purpose), a system for transforming the power, a system for storing the working medium and a cooling-radiator unit. In contrast to space propulsion systems with liquid-fuel or nuclear motors, an electric rocket motor propulsion system is a complex power-production system which combines a highly efficient electric rocket motor with a powerful onboard power-production unit.

In order to provide power to the electric rocket motor, power sources and electric-power transformers are required which possess a great deal of mass that increases in proportion to the increase in the necessary thrust and specific impulse of the motor. For this reason, for the launch masses that are possible at the present time, electric rocket motors are low-thrust motors which in exixting experimental prototypes do not exceed a few dozen kilonewtons. Since the thrust created in an electric rocket motor propulsion system is considerably less than the weight of the unit on the earth, this unit can only be used as a space propulsion system under weightless conditions (after the spacecraft has been placed into artificial earth-satellite orbit) and is efficient when used for flights of great duration. An electric rocket motor system is characterized by its highly economical expenditure of the mass of working medium stored onboard the spacecraft, it being the case that for each spacecraft there exists an optimal value for the effective rate of discharge. This property is a consequence of the division of the sources of power and the working medium.

It is expedient to use electric rocket motor propulsion systems on flights that require relatively large expenditures of energy and are not limited with respect to time: during the transport of heavy cargoes from low near-earth orbit to a geostationary orbit or from the orbit of an earth satellite to a near-earth orbit; or on automatic stations during flights to the far planets. According to the specialists' estimates, the application of an electric rocket motor on an interorbital transport craft serving a geostationary orbit makes it possible to increase the craft's mass ratio with respect to the payload to 70%, as opposed to the 25% of interorbital transport craft with liquid-fuel rocket motors (during flights of 170 and 7 days' duration, respectively).

The application of electric rocket motors will be particularly advantageous for transporting large sections of satellite solar power stations to geostationary orbit after they have been assembled in a stable near-earth orbit. In the first place, one can use in an electric rocket motor the solar power generated by the very elements of the satellite solar power station being transported. In the second place, electric rocket motors will provide for the possiblity of transporting cargoes using small rates of acceleration against the stations's assemblies. This will reduce considerably the strength requirements placed on the large-scale elements of the satellite solar power station and, correspondingly, will reduce significantly the mass of these elements.

Fig. 5 presents the typical design layout of a booster stage with an electric rocket motor propulsion system and a nuclear-reactor power generator. The stage is configured in the form of sequentially connected compartments situated inside a cone, the apex of which holds the reactor-generator (the principle of radiation construction). The electric-power transformers and the compartment for the electric rocket motor are located behind the reactor-generator and the "shadow" shielding protecting against its radiation. In order to discharge unused thermal energy, there is a cooling-radiator unit within which is situated the compartment containing the working medium. The instrumentation compartment and the payload compartment are located farther back, at the greatest distance from the reactor-generator. The radiation construction of the stage insures a minimal mass for the radiation shielding.

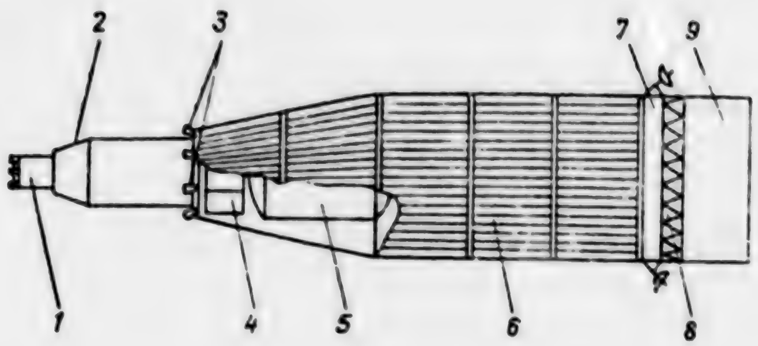

Fig. 5. Design layout of booster stage with a nuclear electric rocket motor: 1- Reactor-generator, 2 - "Shadow" shielding, 3 - Electric rocket motor, 4 - Electric-power transformers, 5 - Tank with working medium, 6 - Cooling-radiator unit, 7 - Instrument compartment, 8 - Framework, 9 - Payload compartment

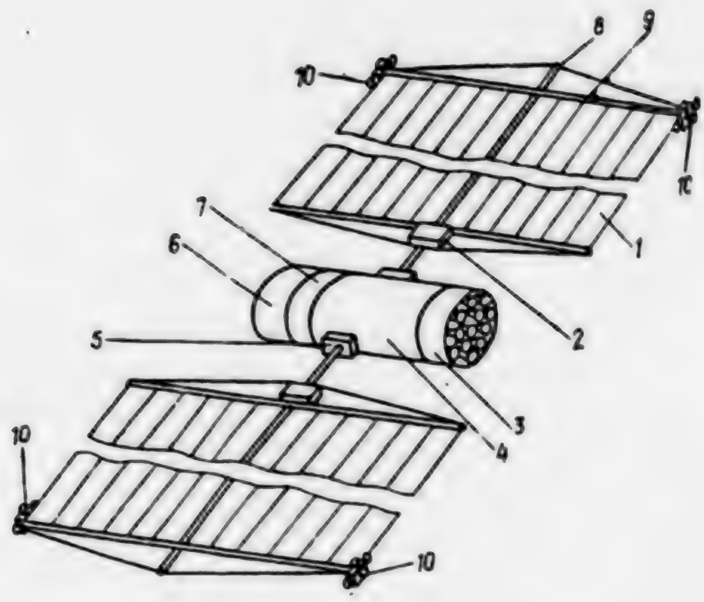

Fig. 6. Design configuration of a booster stage with a solar electric rocket motor propulsion system: 1 - Solar battery panel; 2 - Unit for switching and transforming voltage; 3 - Compartment with electric rocket motor; 4 - Tank system for storing the working medium; 5 - Rotating drive for central unit with sliding contacts; 6 - Payload compartment; 7 - Instrument compartment; 8 - Mast; 9 - Yard; 10 - Attitude control units for electric rocket motor

Fig. 6 presents a typical layout of a booster for a panel-type solar electric rocket motor unit with flat film photocells. The structure supporting the photocell is a flat panel with spars and yards. Between two such symmetrical panels are located a central unit that includes a system of tanks for storing the working medium, the electric rocket motors, various pieces of equipment and the payload. Between the solar batteries and the central unit is a unit for switching and transforming the electric voltage. The central unit can be rotated relative to the solar batteries with the help of a rotating drive. In this case, the electrical current arrives at the central unit through special sliding contacts.

Also being examined are solar electric rocket motor propulsion systems with parabolic solar energy concentrators and turbomachines (operating according to the Brighton or Rankine cycles) and thermal emission transformers.

Flights in the Atmosphere With Electromagnetic Engines

Although efficient transport operations in near-earth space (interorbital transport) can be increased in the future by making the transition to more powerful rocket motors--nuclear and electric--the development of a space transport system for flights along the route from earth to artificial-satellite orbit presupposes first of all the extensive utilization of resources in the earth's atmosphere. We have already mentioned the designs for space planes that use their aerodynamic performance and ramjet engines for a portion of their acceleration in the atmosphere. Another direction in the utilization of the atmosphere's resources, in the opinion of some foreign researchers, is the creation of a space transport system using an electromagnetic engine that generates an electromagnetic field in the surrounding atmosphere in order to derive its thrust.

The mechanism for creating thrust using an electromagnetic engine is associated with effects brought about by highly excited atoms and molecules. The excited atoms are formed by selective absorption of photons (generated, for example, with the help of a flashtron) which transmit the energy to the outer electrons (the life of the excited atoms varies from several milliseconds to one second). It is assumed that one can use the intensive radiation to create excited molecules of nitrogen, water vapor and oxygen in the atmosphere surrounding the electromagnetic engine.

The excited molecules, called excitrons, are easily ionized. The acceleration of these molecules is provided by the action of an alternating electromagnetic field of a specific frequency. Colliding with the other molecules in the surrounding gaseous environment, the excited molecules cause them to move as well. As a result, the entire mass of air in the zone affected by the oscillating electromagnetic field is accelerated, which is accompanied by the initiation of thrust for the space plane. With an electromagnetic field potential of 100 kW/m, a magnetic induction of 1 T and a working frequency of several dozen megahertz, a thrust of 1,000 N per 1 m of air arises. One can judge the efficiency of this type of space transport system by comparing the American design for a space plane possessing an electromagnetic engine with the Space Shuttle reusable space transport. Although for the latter the ratio of power expended to the thrust created is 4,500 W/t, the future electromagnetic engine would be

able to provide this value at a level of 300 W/t (with the condition that the increase in velocity of the air surrounding the space plane is approximately 300 m/s).

It is proposed that a combined propulsion system be employed on a space plane in which the lift and the thrust are provided for by the combined effects of aerodynamic forces, the forces of the electromagnetic field and the thrust of a liquid-fuel rocket motor. In principle, it is possible to use the electromagnetic field to decelerate the space plane upon its return to earth as well. A space plane with an electromagnetic engine is designed for horizontal takeoff and landing and constitutes a biplane between whose wings an electromagnetic field is generated. A high-frequency magnetogas dynamic (MGD) generator is located onboard to produce the electric power. A quartz flashtron and mirrors are employed to excite the air molecules (without ionization).

In accordance with the design, the MGD generator uses the combustion products of a liquid-fuel rocket motor operating on liquid hydrogen and liquid oxygen. A readily ionized admixture (additive) in the form of potassium compounds is supplied to the combustion products. The plasma with the ionized additive moves in a MGD channel at a speed of 3-4 km/s. The MGD channel has two pairs of electrodes, each of which is connected to a corresponding electrode on the wing of the space plane and insures the effect of a high-frequency electrical field on the surrounding air. In addition, a portion of the energy from the field created by the magnet coils of the MGD channel is intended for this purpose. Under the effect of the electrical and magnetic fields, the air between the wings of the space plane moves parallel to the flow of plasma in the MGD channel. The coils, the superconducting magnet and the walls of the MGD channel are cooled by liquid hydrogen.

The layout of the apparatus for creating the electromagnetic field between the wings of the space plane and the layout of the optical system on the wings are presented in figures 7a and b. An overall view of the space plane with its electromagnetic engine is provided in fig. 8. With a payload of 29.5 t, its launch mass is four times as great as that of the Space Shuttle reusable space transport and amounts to 570 t, of which the fuel accounts for 400 t, the electrodes and the coils on the wings 45 t and the MGD channel and the magnet 13.5 t.

This type of space transport system can be used in the future in passenger or passenger-freight versions for serving large-scale orbital stations and assembly centers. Together with the problems of developing a space transport system with electromagnetic engines, however, we must also investigate the questions of crew safety onboard the craft and the effect of space transport flights on the environment from the point of view of possible ecological damage in the atmosphere.

Space Transport Systems Based on Electromagnetic Mass Accelerators

In the previous sections we examined designs for space transport systems for which all or the greater portion of the mass and energy needed for acceleration are stored onboard the booster. The scale of transport shipments in the epoch of the industrialization of space (on the order of 1 million tons per year),

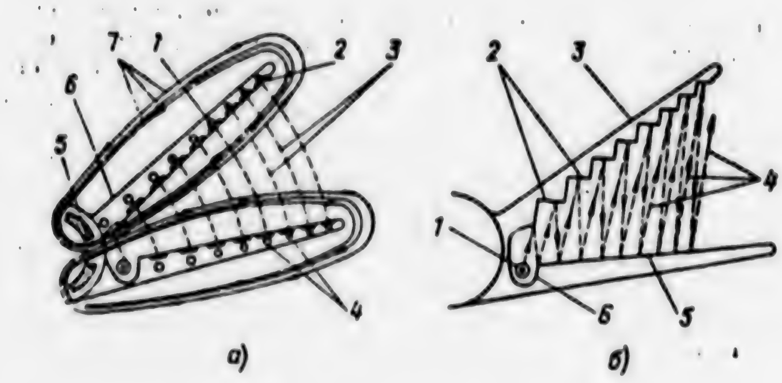

Fig. 7. Layout of the apparatus (a) for forming the electromagnetic field between the wings (1 - Conductors, 2 - Metal electrodes, 3 - Lines of the electromegnetic field, 4 - Wing coils, 5 - Coils of the MGD generator magnet, 6 - Insulation, 7 - Magnetic field lines of force) and the optical system (b) on the wings of the space plane (1 - Flashtron, 2 - Fresnel reflectors, 3 - Wing, 4 - Radiation field, 5 - Plane mirror, 6 - Reflector)

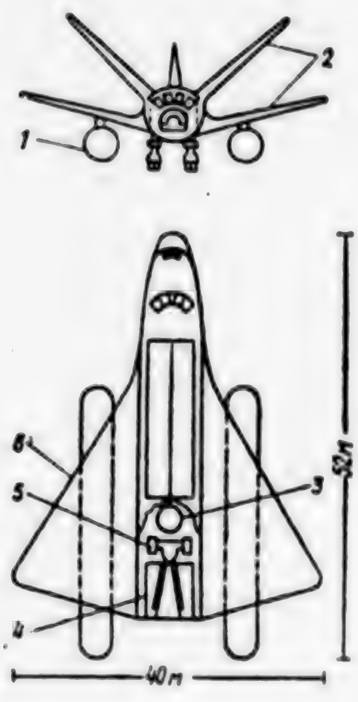

Fig. 8. Overall view of the space plane with electromagnetic engines: 1 - Underwing fuel tanks, 2 - Wings, 3 - Tank with ionizing additive, 4 - MGD channel and magnet, 5 - MGD sustainer propulsion unit

however, compels us to seek other, more efficient principles for developing the space transport system of the future. With the tremendous outputs of satellite solar power stations whose creation is proposed in this period, the launching and utilization of external energy resources may prove to be just such a principle.

Of primary interest in this direction is the investigation of a second (non-reactive) means of delivering cargoes into space which was indicated in 1933 by K. E. Tsiolkovskiy in his work, "Projectiles Which Achieve Cosmic Velocities on Land and Water." In a special electrical accelerator-cannon located on the earth, a projectile with a payload would be accelerated to a velocity exceeding the cosmic velocity and, after passing through the atmosphere, would arrive in artificial-satellite orbit. K. E. Tsiolkovskiy noted such advantages of this method as the elimination of "the great reserve of explosive elements," that is, of the chemical fuel that comprises the greater portion of the launch mass of a liquid-fuel rocket; the consumption of electric power from ground-based structures; and the repeated utilization of the accelerating apparatus.

During this period, however, this principle was not realized in specific engineering terms. Even at the present time, the designs for such accelerators are staggering with respect to their dimensions and their power demands and require that we continue to pursue the means to achieve their efficient technical realization.

At the present time, it is believed that the most acceptable arrangement for transporting a great volume of freight into space based on a non-reactive method is the electromagnetic mass accelerator which is similar in layout to a magnetic propulsive device. A container with the payload, fitted with superconducting solenoids, accelerates along an immovable conducting track due to the interaction of electromagnetic fields created by the container and the track. The electromagnetic mass accelerator must be provided with a source of power and power-distributing and switching equipment. There are cooling and control systems on the accelerated container with its superconducting coils which create a high-intensity electromagnetic field. A special segment of track is included in order to decelerate the container after the mass which had been accelerated separates from it. A schematic diagram of the electromagnetic mass accelerator is presented in fig. 9.

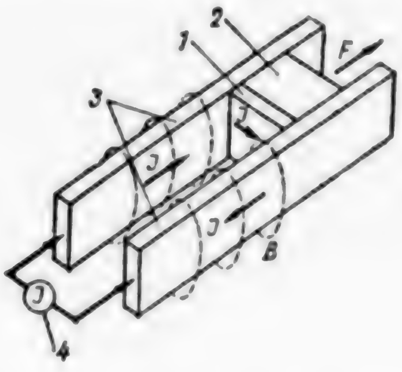

Fig. 9. Schematic diagram of the electromagnetic mass accelerator: 1 - Moveable carrier element with accelerated capsule (2), 3 - Rigid conducting guide rail, 4 - Current source

Two versions of the electromagnetic mass accelerator are known: accelerating coils of rectangular (planar) shape which are located along both sides of the accelerated container; and hoop-shaped accelerating coils coaxially located with respect to the container. It is easier to carry out a number of operational measures in the first version (simpler access to the container, the coils, etc.). It is likewise easier to maintain precise control over the degree and direction of the velocity of the acclerated payloads, which is an important factor in realizing and utilizing the transport system as a whole. The second version attains an even higher degree of efficiency in accelerating mass.

A high vacuum and low temperatures, that is, the conditions found in space, are ideal conditions for the operation of an electromagnetic mass accelerator. For the ground-based version of the electromagnetic mass accelerator, it is necessary to consider the projectile capsule's loss in initial velocity during passage through the atmosphere. Here the picture of events is the opposite of the traditional picture when a spacecraft enters the planet's atmosphere: the capsule, accelerated by the electromagnetic mass accelerator, passes through the densest layers of the atmosphere at maximum velocity. In the upper layer of the atmosphere, however, it moves with its lowest speed, since the most intensive thermophysical and chemical processes take place at altitudes up to 30 km.

What are the characteristics of such an arrangement, the creation of which is theoretically possible in the future but will require the solution of a number of complex scientific and technical problems?

A ground-based electromagnetic accelerator for boosting projectiles weighing 60 t to a speed of 10 km/s requires a power (the projectile is accelerated in 2 s) of about 3,000 GW, that is, more than the installed capacity of all the electric power stations in the USSR and the United States. For this reason, a gigantic power-storage device is required for supplying power to the accelerator. If, for example, a storage-device such as the Krasnoyarsk hydroelectric power station were connected, it would be possible to send one projectile into space every half an hour, delivering 11 million tons of cargo to artificial-satellite orbit in 10 years.

Of interest is the American design for an electromagnetic mass accelerator to be used for transporting cargo from the moon (for example, raw materials in the form of minerals for the space production of the panels of solar batteries and the structural elements of satellite solar power stations). With an impulse frequency of 1 GHz, the system can insure the acceleration of payloads with a mass of 20 t to a terminal velocity of 2.4 km/s and have an output of 600,000 t per year. A high aiming accuracy is assumed (±1 m at a distance of 63,000 km from the moon), which would facilitate the condition that the payload modules be received at the terminal point (in geostationary orbit, for example).

The results of experimental research in this area have been very encouraging. A group of physicists at the Australian National University (Canberra) together with other specialists have conducted tests of a "rail gun" several meters long. It essentially is the simplest of the electromagnetic microparticle accelerators. This device consists of two current-conducting rails mounted in something similar to an artillery barrel. Pulses of electromagnetic current sent along

one rail return along the other. The first version of the rail gun had a sliding conducting connector between the rails which was set into motion by the force of the interaction of the magnetic field due to the current flowing along the rails with the current in the bridge.

It was shown during the course of the experiments that the metal bar could be replaced by an electric arc--a plasma discharge--moving between the rails. A small projectile of a nonconducting material--plastic--will be pushed along ahead of this plasma. In the plasma rail gun, the spacialists succeeded in accelerating a cubic centimeter of plastic to a velocity of 6 km/s. To further accelerate the projectile, it proposed that power-storage devices be situated and sequentially connected along the barrel of the gun, since supplying power from one end of the barrel leads to considerable losses due to electrical resistance when the length of the rails is sufficiently great.

Thus, the experiments confirm the feasibility of constructing an electromagnetic mass accelerator for boosting payloads to space velocities. Electromagnetic mass accelerators in combination with satellite solar power stations as power sources can basically solve the problem of delivering cargoes into space and are ecologically clean space transport systems. Among the shortcomings of such a method of orbiting payloads one must include the excessively high G-loads that place limitations on the types of payloads; that is, electromagnetic mass accelerators are basically intended for transporting raw materials and semi-finished goods.

The Laser in Service to Space Transport

There is yet another efficient means for the mass launch of payloads into space, a method with acceptible G-loads--the application of space transport systems using laser rocket motors. At the basis of the laser rocket motor's operation is the principle of the external supply of power with the help of a beam of finely focused laser radiation to heat the working medium located onboard the space transport system. The flight of the space transport system proceeds according to a previously programmed trajectory, while the necessary orientation of the power transmitter and receiver is achieved through a feedback tracking system. In this case, the source of laser radiation can be located on the surface of the earth as well as in space. An onboard system of the laser rocket motor contains a laser-beam concentrator and a light-guide which conducts the beam energy to the zone where the heating takes place.

The working medium is heated with the help of the energy of the laser radiation to very high temperatures and is discharged outwardly through a supersonic nozzle at great velocities (the specific impulse of a laser rocket motor can reach 1,000 to 2,000 s.). For economic and ecological considerations, it is convenient to chose a working medium such as water, for example.

Studies of the technical aspects of the problem of creating a laser rocket motor at the present time encompass the following basic directions: the study of the feasibility of using two alternative operational modes of the laser sources, pulse and continuous; and the theoretical and experimental study of the various mechanisms for heating the working medium with laser radiation. Two space transport system configurations are possible on the basis of the laser rocket motor, differing in the method of conveying the laser beam to the motor chamber (fig. 10a, b).

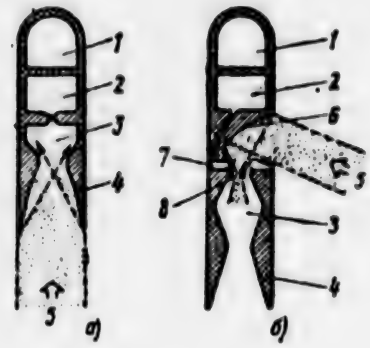

Fig. 10. Layout of a space transport system using a laser rocket motor (a - One-way; b - Two-way): 1 - Payload, 2 - Working medium, 3 - Absorption chamber, 4 - Nozzle, 5 - Laser beam, 6 - Focusing mirror, 7 - High-pressure chamber, 8 - Supersonic aerodynamic window

In the first case, the laser beam arrives through the motor's nozzle without, however, losing its energy in passing through the nozzle and the stream of exhaust products (this configuration is called one-way). In the second case (two-way), the laser beam arrives at the motor through an aperture on the side and falls on a focusing mirror which deflects it and directs it into the aerodynamic window. The window passes the laser beam into the absorption chamber but impedes the flow of gas from the high-pressure chamber. In doing so, the window must operate under conditions in which there is a constant decrease in the pressure of the environment (along the flight trajectory).

The working medium is delivered from the tank to the motor's chamber where it is heated with the help of laser radiation energy. In order to increase the degree to which the laser radiation is absorbed by the stream, a small amount of gaseous additives can be introduced. The high-temperature plasma formed in the heating zone discharges through the nozzle, where it creates reactive thrust.

For steady-state (continuous-operation) laser rocket motors, the most flexible arrangement with respect to the operating parameters and the performance characteristics is the two-way configuration. The one-way scheme for delivering the laser energy is more suitable for the impulse laser rocket motor. As foreign experts have proven, the efficiency with which the laser energy is converted into thrust in an impulse laser rocket motor is somewhat less than the efficiency of a continuously operating laser rocket motor. Thanks to the simplicity of its construction (conduction of the laser beam through the exhaust tract) and the absence of possible problems associated with limitations regarding the plasma's stability, however, the impulse laser rocket motor possesses potential advantages over steady-state laser rocket motors.

It has been proposed that satellite solar power stations be employed as the primary source of energy for space transport systems with both laser rocket motors

and for electromagnetic mass accelerators. In this case, two methods for utilizing this energy are possible: the direct transmission of energy generated by the satellite solar electric power station along a laser beam to the rocket and the transmission of the energy of a satellite solar power station through an energy-storage device. Relatively small payloads (1 to 10 t) can be placed into orbit around the earth using the first method with a standard satellite solar power station output of 10 GW and practicable efficiencies.

The mass of the payloads launched can be increased considerably by means of the construction on earth of a special power-storage facility (using superconducting elements, hydroaccumulators, etc.), transformers and a bank of high-output lasers. For example, a payload weighing 100 t and a space transport system with a launch mass of approximately 200 t can be launched into space with the help of a space transport with a laser rocket motor possessing an exhaust velocity of the working medium (water vapor) of 20 km/s. In this case, it is necessary that an output of 100 GW be delivered to the working medium in the laser rocket motor in order to accelerate it to 20 km/s. The mass of the ground-based laser unit transmitting the power to the rocket (from a calculation of a specific installation mass of approximately 1 kg per kilowatt of transmitted energy) amounts to 100,000 to 300,000 t.

In order to transfer payloads from low near-earth orbit to a geostationary orbit with the help of a space transport system with a laser rocket motor, it is suitable to use laser installations situated in space, since ground-based installations require that very high levels of power be transmitted due to the necessity of compensating for losses as the laser beam passes through the atmosphere.

Obviously, the realization of the designs listed above which provide for the mass launch of payloads into space and which are associated with the construction on earth of technically complex installations that are gigantic in scale will require great capital expenditures amounting to tens of billions of rubles and which will not provide an economic effect at first. It is appropriate that we cite Academician V. P. Glushko's opinion in this connection: "They may object. It will cost a great deal of money, for example, to bring a ton of minerals from the heavens. However, doesn't the first ton of coal taken from a modern mine cost the same amount of money today? Thousands of tons, however, are cheaper, while millions will cost kopecks."

Space Transport Systems and Interplanetary Flights

The mastery of near-earth space in the epoch of industrialization encompasses the creation of satellite solar power stations in geostationary orbit, the construction of fuel and power bases on the moon, the creation of permanent orbital space stations and assembly and operation centers and, finally, the deployment in near-earth and lunar space of a network of automatic relay satellites which would practically turn the entire region between the earth and the moon into a gigantic antenna system capable of controlling the movement of spacecraft in the Solar System and even beyond its boundaries. All of this, naturally, will contribute to the further development of planetary research and the study of interplanetary flights. The requirements for space transport systems which carry out interplanetary flights, however, differ considerably from the requirements placed on space transport systems in near-earth space.

Although the basic mission of near-earth space transport in the future is the realization of a heavy flow of cargo traffic with minimum expenditures and without damage to the ecology of the environment, the question of insuring the necessary power for the flight (from the point of view of both the mass ratio of the space transport with respect to the payload and the time of the flight) will be acute for interplanetary space transport systems, as it has been in the past. In comparison, let us point out that the launching of an artificial earth satellite to low geocentric orbit (considering all the losses) requires an acceleration to 9 km/s; a flight to the moon (one way) requires a velocity of more than 12 km/s; and a trip to Venus or Mars requires no less than 40 to 50 km/s.

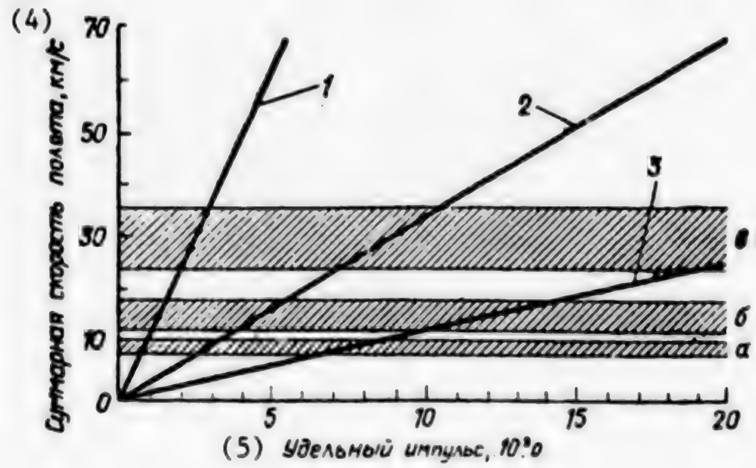

Fig. 11. Connection between the required specific impulses and the ultimate flight velocity for various values of the relative payload mass (a - Launch to artificial-satellite orbit, b - Launch to Venus or Mars, c - To Mercury or Jupiter): 1 - 0.25 to 0.35, 2 - 0.5 to 0.6, 3 - 0.65 to 0.75, 4 - Ultimate flight velocity, km/s, 5 - Specific impulse, 10^3 s

It will be necessary to seek out more efficient propulsion systems for interplanetary space transport systems. Fig. 11 shows the specific impulse (depending upon the ultimate "velocity reserve") necessary for flights with a specific payload mass for the given distances. One can see that for flights to Venus, Mars, Jupiter and Mercury with a relative payload mass of 0.5, the required magnitude of the specific impulse should amount to 4,000 to 9,000 s. In this case, the motors must insure enough thrust-producing capability to reduce the time of interplanetary flights to acceptable values. Such a requirement can be satisfied by impulse (pulsing) nuclear rocket motors. We will first of all examine further space transport systems utilizing such motors.

Transport Vehicles Using Impulse Nuclear Rocket Motors

These unusual motors are devices in which it is proposed that the thrust be created by utilizing the energy of the explosions of a great many nuclear charges of comparatively low yield carried onboard the space transport system. These

charges are jettisoned sequentially from the transport craft and detonate behind it at a certain distance, on the order of several dozen or hundreds of meters. During each explosion, a portion of the gaseous fission fragments in the form of high-density, high-velocity plasma strike the base of the craft--a special buffer plate fitted with shock-absorbing devices. The motion of the fragments is is transmitted to the buffer platform, and the latter moves forward with a great acceleration.

The buffer devices in a piloted space transport system can reduce the acceleration and insure an acceptible level of G-loads in the area of the crew compartment. After the compression cycle, the shock absorbers return the pusher platform to its initial position, after which it is again ready to receive the next pulse. The total increase in the velocity of such a craft depends upon the reserve of nuclear charges carried onboard (fig. 12).

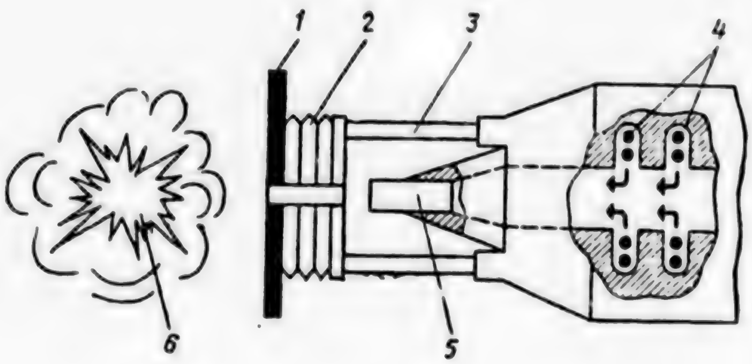

Fig. 12. Principle of operation of an impulse nuclear rocket motor: 1 - Buffer plate, 2 - Pusher platform, 3 - Piston-type shock absorber, 4 - Stores of nuclear charges, 5 - Charge-jettisoning mechanism, 6 - Detonation of the nuclear charge

The thrust can be created not only through the immediate action of the striking particles (products from the explosion) but also through the transmission of their kinetic energy to a working medium being discharged from the nuclear rocket motor. For example, a solid substance carried on the buffer plate which is easily converted to a gas can be used as the working medium, or liquid hydrogen specially delivered from a tank. Due to the brief duration of the effect from a single detonation (approximately 1 ms), elevated temperatures in the working zone can be tolerated (up to $8 \cdot 10^4$-10^6 °K). In order to increase the specific thrust of pulsing nuclear rocket motors, it is expedient to use charges of a special shape (in order to direct the blast) as well as to enclose the charges in special casings (upon whose instantaneous vaporization a shock wave would be formed). Theoretical estimates give the specific impulse of pulsing nuclear rocket motors using ordinary nuclear charges (with fissionable material) as 2,500 to 5,000 s.

Despite its unusual principle of operation, the impulse nuclear rocket motor is viewed as an entirely practicable propulsion arrangement. An assessment of the potentials of such a motor was conducted in the United States during the development of Project Orion in the 1960's. This project envisioned the creation of a space rocket using an impulse nuclear rocket motor which employed the energy of plutonium-bomb explosions. According to the calculations, such a rocket with a launch mass of 3,600 t could insure the delivery of a payload weighing 680 t to the surface of the moon. This would require that 800 bombs be exploded, and this would amount to only 800 t of propulsive mass (considering that an easily vaporized, light-molecule substance would be applied to the buffer plate). The feasibility of accelerating a spacecraft by means of a series of consecutive explosions was confirmed experimentally on a flying model set into motion by the energy of explosions of TNT charges.

At the present time, specialists link the advanced impulse nuclear rocket motor with the utilization of thermonuclear charges that are more efficient than ordinary nuclear charges. In contrast to the latter, thermonuclear charges have a minimum of mass and, consequently, their power is not limited by the requirements of criticality. Moreover, the thermonuclear charges of impulse rocket motors can use deuterium-tritium fuel, the complexity of application of which in ordinary nuclear rocket motors was noted above. It is proposed that a laser beam or a powerful electron beam passing through a self-focusing magnetic field be used to detonate the blasts. The specific impulse of an impulse nuclear rocket motor with thermonuclear charges, according to the estimates, is from 5,000 to 10,000 s.

The basic requirements placed upon interplanetary space transport systems with such motors are single-stage configuration, reusability, the capability of carrying out flights within the boundaries of the Solar System (including the planet's atmosphere), a relative payload mass of not less than 20% and the capability of using several types of fuel as the working medium, which would simplify refueling operations when landings are made on other planets. For example, together with hydrogen, impulse nuclear rocket motors can use water as a working medium, which provides a sufficiently high specific impulse. Water is easily stored and is available in abundance on Earth, Mars, the moons of Jupiter and on other bodies in the Solar System. It can be included in the casing of the nuclear charge or can be delivered directly to the gap between the protective shield and shock wave from the blast. In the latter case, the working medium would partially absorb the energy and simultaneously cool the screen. Thus, by introducing greater or lesser quantities of the working medium into the blast zone, one can regulate the motor's thrust.

A shortcoming of space transport systems using impulse nuclear rocket motors is the cluttering of space with radioactive fragments formed during the nuclear blasts. This is why they are proposed for flights far from earth and from inhabited "space tracts." In an effort to avoid contamination of the atmosphere, a number of designs for such systems provide for combined propulsion systems with ramjet engines for takeoffs from the earth's surface.

Interplanetary Space Transport Systems Using Ramjet Thermonuclear Rocket Motors

The principle of operation of any ramjet engine is based upon the capture of the environment, the application of energy to it and the discharge of a reac-

tive mass through a nozzle that accelerates the flow. The concept of a ramjet thermonuclear rocket motor consists of the utilization of the hydrogen existing in interplanetary space for the purpose of thermonuclear fusion and of the transfer of the energy released to a stream of particles captured by a mass-intake from the external environment in order to accelerate the craft. Thus, the duration and distance of the flight of space transport systems using nuclear rocket motors are not linked to the reserves of fuel and energy stored onboard (both are derived from the external environment) and depend only upon the service life of the onboard systems. Even the initial reserves of thermonuclear fuel needed for the launch (deuterium and tritium) can be replenished during the course of the flight from the interplanetary environment where these isotopes of hydrogen are also contained in certain amounts.

The capture of the external environment is accomplished through the ionization of particles of the inflowing stream and with its subsequent focusing with the help of a magnetic field specially formed ahead of the transport craft. For this purpose, the windings of a current-carrying superconducting coil cooled by liquid helium are arranged along the perimeter of a mass-intake that is rather impressive with respect to its dimensions (approximately 20 m in diameter and 25 m in length). A beam of accelerated electrons or some other form of radiation (gamma rays, X-rays or ultraviolet radiation) is directed outwards from the forward portion of the mass-intake's central body.

The inflowing stream of hydrogen is ionized by the radiation. If a beam of electrons is used, this stream is prefocused, drawing in closer to the beam's axis due to the electrostatic effect. The ionized particles in the stream (protons and electrons, basically) are captured by the transport craft's magnetic field and, moving along the field's lines of force, are drawn into the entrance of the mass-intake. The focusing done with the help of the magnetic field considerably increases the mass-intake's effective area. According to estimates, the effective diameter of an advanced electromagnetic mass-intake could reach from several hundred to thousands of kilometers.

With a density of the interplanetary environment of 10^{-17}kg/m^3 and a flight velocity of of 100 km/s, such a mass-intake would collect about 1 kg of hydrogen per second. If 75% of the hydrogen arriving at the intake would react in the thermonuclear unit, the energy released would amount to $5 \cdot 10^{11}$ kJ/s. Considering the possible losses during the magnetic focusing (due to various types of instabilities) and the incomplete utilization of the thermonuclear fusion energy for accelerating the reactive stream, the actual thrust of such a thermonuclear rocket motor would be approximately 1,000 kN and would make it possible for the space transport system to accelerate from orbital near-earth velocities to approximately 1,000 km/s in a limited amount of time. In that case, piloted flight to Mars and Venus could be carried out in 2-3 months, while flights to the outer planets of the Solar System could be accomplished in a few years.

The outward appearance of a space transport system using a ramjet thermonuclear rocket motor is unusual in flight. A bright violet ionized beam extends for a great distance ahead of the transport craft. There are flashes and glows along the periphery of this beam associated with the disintegration of micrometeors and cosmic dust into individual molecules and atoms as they meet the transport

head-on and with their ionization along with the other particles of the interplanetary environment under the effect of the powerful stream of accelerated ions. Collisions with large meteors can be avoided through their early detection and by executing evasive maneuvers. The maneuvering and deceleration of the craft will be carried out by varying the operational mode of the reactor and by directing the "magnetic funnel" of the mass-intake which, under certain conditions, can serve in the role of a brake.

The Photon Rocket

The ramjet thermonuclear rocket motor which we discussed above is not limited in principle to its range and can be examined as a means of carrying out interstellar flights as well. According to modern data, however, the density of interstellar hydrogen is considerably lower than the interplanetary density (10^{-21} instead of 10^{-17} kg/m^3). For this reason, the thrust of such a motor in an interstellar environment does not exceed several newtons, and this is unsuitable for piloted space transport systems due to the very long duration of the flight. The gradual acceleration of the space transport system may likewise not lead to a higher level of thrust, since a greater portion of the energy generated onboard the space transport will be expended on increasing the intensity of the mass-intake's magnetic field as the speed of the inflowing stream increases.

An improvement in the power performance of the motor in this case appears to be possible by making the transition from the thermonuclear fusion of hydrogen to a reaction involving the annihilation of hydrogen and antihydrogen. In this case, the release of energy is approximately 1,000 times as great as in hydrogen fusion. If the radiation thus formed is focused in one direction in a beam, similar to the exhaust from a nozzle of a reactive motor, we obtain a so-called photon engine with a discharge velocity of the working medium approaching the speed of light.

The proportion of antimatter in the external environment is extremely small, therefore antimatter must be stored onboard the space transport system. The problems of obtaining and storing antimatter are far from being solved, however, and have not yet even been placed on the agenda. At the present time, we have no idea how to deliver antimatter to the core of a reactor. The question of the efficient conversion of photon energy into the kinetic energy of a reactive stream is extremely complex.

It is impossible to focus and reflect photons using an ordinary reflector with rigid walls, since the photons from an annihilating substance in their initial form represent high-frequency gamma radiation with high penetration ability, for which even an ideally polished screen appears as a sieve. According to modern thinking, the most promising could be considered the proposal to utilize (for focusing the quanta) a disk-shaped electron cloud maintained by the same magnetic field which insures the operation of the electromagnetic mass-intake.

The possibility of creating a space transport system using a photon engine is a matter for the very distant future. This direction for the development of propulsion systems depends closely upon the success of fundamental and applied research into thermonuclear fusion, high-temperature superconductivity, ele-

mentary-particle field theory, methods of obtaining and storing antimatter, etc. For today, the photon engine is the most energy-productive of all the engines proposed for space transport systems.

On the Possibilities of Flights to the Stars

During the 26 years of practical development of astronautics, man has completed flights of 380,000 km from the earth (flights to the moon) and automatic spacecraft have visited Mars and Venus and have carried out investigations of Mercury, Jupiter and Saturn from their flight trajectories. On 25 April 1983, Pioneer 10 intersected the orbit of Pluto at a distance of 45 billion km from the earth and intersected the orbit of Neptune in June 1983.

However, one can judge how far-reaching and complex the tasks are facing man in carrying out flights to the stars by comparing them to the successes achieved in the investigation of near-solar space, only visually imagining the scale of interstellar distances. A beam of light from Proxima Centauri, a small, reddish star nearest to us in the Alpha Centauri star system, takes 4.27 years to reach the earth, and the distance from this star to the earth is 270,000 times greater than the distance from the earth to the sun. If, for the sake of illustration, the Solar System were reduced in its entirety to the size of a postcard, that is, to 12 cm in diameter, our galaxy would be reduced correspondingly to 9,000 km in cross-section, that is, it would cover approximately the territory of the Soviet Union, and the nearest star to us, Proxima Centauri, would be at a distance 500 m from the postcard. In order to leave the Solar System, a space transport system must be able to provide an escape velocity relative to the earth of approximately 16.7 km/s. Even with a flight at a velocity of 20 km/s, however, 66,000 years would be required to reach the nearest star.

The impossibility of such a trip is obvious. In order to reduce the time, it is necessary to increase the flight velocity. Since we are dealing with distances that take a beam of light years to travel, space transport systems on interstellar flights must develop velocities approaching the speed of light. If one takes the lifetime of one or two human generations (approximately 30 to 60 years) as the flight duration, then a flight to Proxima Centauri would require the values of accleration and velocity presented in table 2 (allowing for continuous acceleration during the first half of the journey with subsequent deceleration).

If one now were to calculate the necessary energy expenditures to realize piloted flights using known and future propulsion systems, the calculation of the fuel required for the flight of an interstellar craft weighing 1,000 t according to the flight program least stressful to man (with an acceleration of 0.2 m/s^2) would amount to $37 \cdot 10^{11}$ t for a chemical motor, $38 \cdot 10^{4}$ t for a nuclear motor, $48 \cdot 10^{3}$ t for a thermonuclear motor and $2 \cdot 10^{2}$ t for an antimatter motor. In actuality, only the latter variant can be acceptable with respect to the mass of the space transport system and the necessary mass of fuel, but it is practically not feasible. In order to imagine how great the energy required for this flight is, it is sufficient to note that over the course of the last 20 centuries mankind has expended for its own energy needs as much enegy as would be obtained from the annihilation of 100 t of antimatter, that is, one-half the supply of fuel necessary for a piloted flight to Proxima Centauri.

Table 2. Characteristics of a Space Transport System Flight to the Star Proxima Centauri

Acceleration	$0.2\ m/s^2$	$0.4\ m/s^2$	$1.0\ m/s^2$
Greatest attainable velocity, km/s	$0.9 \cdot 10^5$	$1.26 \cdot 10^5$	$2 \cdot 10^5$
Time of the trip for the crew (both ways), years	56.8	40.0	25.3

Nevertheless, man's quest for "light and space" continues. Basic and evaluative research is being conducted abroad as well. We know of the American design for a two-stage interstellar space transport system using an impulse nuclear rocket motor. With a first-stage launch mass of 48,000 t and a second-stage mass of about 5,000 t, this system provides for accelerating a craft with a mass of 500 t to a velocity equal to 0.122 times the speed of light.

There are proposals to use laser ramjet engines in space transport systems for interplanetary flights. In these engines, the energy for heating and accelerating the plasma is delivered to the craft from intermediate near-solar orbit by a laser beam created by a device deriving its energy from the sun. It is proposed that the laser propulsion system be utilized on segments of an acceleration run to the speed of light with a simultaneous gathering of interstellar deuterium for the operation of a pulsing thermonuclear rocket motor. The estimate of the mass of such a space transport system is very approximate. As a rough estimate, we will say that the value for the launch mass is on the order of 8,000 t, while the mass of interstellar matter gathered during the flight amounts to 12,000 t. This being so, the necessary output of the laser beam must be equal to $3.5 \cdot 10^8$ MW. In this case, the dimensions of the solar batteries in near-earth orbit needed to supply the laser exceed 500x500 km, while the diameter of the intake on the ramjet engine installation onboard the space transport is about 650 km.

Thus, even with the boldest technical forecasts and designs, piloted flights to the stars are still a practically impossible task. However, did not the problems associated with man's first flight to the moon or with the launch of automated spacecraft to the far planets also seem as complex and immense at first?

The mastery of space continues. New problems face the space transport, yet, at the same time, new potentials are opening up as well. The deployment of satellite solar power stations in the future will allow us to make the transition to qualitatively new types of space transport systems with the utilization of external sources of power (electromagnetic mass accelerators and laser motors) which will insure the realization of great flows of cargo in near-earth space.

The development of nuclear power engineering in the future will lead to the creation of space transport systems using thermonuclear rocket motors (pulsing and ramjet) which will open up broad possibilities for piloted flights within the limits of the entire Solar System.

Improved space transports using traditional propulsion systems will find their application as well. Transport systems using liquid-fuel rocket motors and external resources (atmospheric) will be able to effectively solve new problems of piloted flight and the launch of applied artificial earth satellites into near-earth space, while nuclear and electric-rocket space transport systems will be able to carry out the interorbital transport of freight and unpiloted flights into deep space. Decades more will go by, and the problems regarding flights to the stars may prove to be very critical for predicting the development of space transport systems from the standpoint of new achievements of science and technology. The improvement of transport systems will continue together with the exploration of space.

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9512
CSO: 1866/63

DESIGN CONCEPTS FOR FUTURE MODULAR SPACE STATIONS

Leningrad LENINGRADSKAYA PRAVDA in Russian 12 Apr 84 p 4

[Article by M. Chernyshov]

[Abstract] The article, which is published on the occasion of Cosmonautics Day, traces progress in the development and use of manned space stations and orbiting complexes for research purposes. Comparative data on the specifications and equipment of the "Salyut-6" and "Salyut-7" stations are cited, as well as data on results of research performed on these stations.

Turning to types of space stations and orbiting complexes which are contemplated in the future, the article states: "Each direction of space research, as it develops, requires that stations are more and more subordinated to its specific interests: for Earth-resources studies, a station must 'look' constantly at the Earth; for astrophysics, it must 'look' at the stars. Moreover, the presence of cosmonauts is absolutely necessary for certain types of work and, conversely, their presence is undesirable in other cases. It is already clear to specialists that a harmonious compromise in meeting all of these contradictory requirements can be achieved only on the basis of multiple-module stations, although multiple-modularity, as we have said, does not mean that all modules must necessarily be linked rigidly into a single cluster. Some of them can be in independent flight, and they will dock only for short periods of time, for maintenance or repairs. Some may not dock with a station at all, but will only be visited periodically by cosmonauts from a central base-station. The central nucleus of the station itself will no longer look like a scientific laboratory, filled to the limit with various kinds of apparatus. More likely, it will be a kind of living area with the most comfortable conditions that are possible in space."

FTD/SNAP

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DESIGNER OF 'KRT-10' RADIO TELESCOPE

Moscow VECHERNYAYA MOSKVA in Russian 17 May 84 p 2

[Photo caption]

[Text] Scientists and associates of the Central Scientific Research and Design Institute of Metal Structures for Construction and specialists of other organizations have designed a series of 350-meter television towers for Leningrad, Kiyev, Yerevan, Tbilisi, Alma-Ata and Tashkent.

A space radio telescope, the "KRT-10", operated on the orbiting complex "Salyut-6". Scientists and engineers of the institute developed an antenna 10 meters in diameter for this telescope.

(The photograph shows Candidate of Technical Sciences A. Gvamichava, a senior science associate of the institute and chief design engineer for metal structures of the "KRT-10".)

FTD/SNAP

CSO: 1866/148

ADVANTAGES OF METALLIC FUELS FOR ROCKET PROPULSION

Moscow KHIMIYA I ZHIZN' in Russian No 12, Dec 83 pp 80-84

[Article by Ya.I. Karker, doctor of technical sciences, and G.Yu. Mazing, doctor of technical sciences: "Metals As Fuel"]

[Text] Selecting the most efficient fuels and oxidizing agents is a paramount problem in space rocket technology. And the main energy index determining the efficiency of a rocket fuel is the exhaust velocity of the combustion products discharged from the nozzle. The greater the velocity the greater the engine thrust for a given fuel consumption, the less the fuel reserves required to achieve a given flight velocity and the greater the payload that a rocket can carry into orbit around the Earth or the planets of the solar system.

Better Fuel.

Exhaust velocity U is directly linked to the amount of heat Q that is given off during combustion per mass unit of combustion products. And the heat given off depends on the calorific power of the fuel (H) and the amount of oxidizing agent needed for its complete combustion (O/C):

$$Q = \frac{H}{1 + O/C.}$$

The calorific power of the elements depends on their numbers in the periodic table: high levels of calorific power alternate with dips, and as the number on the periodic table increases the high levels become lower and lower. Obviously only the elements in the first two sequences can be regarded as fuels. They include hydrogen, beryllium, boron, carbon, lithium, aluminum and magnesium. Among them, hydrogen undoubtedly is without competition, because its calorific power is double to quadruple that of the others. This is also associated with the relatively high calorific values of the hydrocarbon fuels, as for example kerosene and gasoline.

Now let us consider how things stand with another very important characteristic of fuel, namely the O/C relationship. Here the metals have no competition: the oxygen required for the complete combustion of 1 kilogram of aluminum is only one-third of that required to burn 1 kilogram of carbon, and 3.8 times less than that required to burn 1 kilogram of kerosene. Therefore, for metals Q is somewhat higher than for other fuels. Even aluminum and magnesium with their low calorific power can compete quite well with the hydrocarbons.

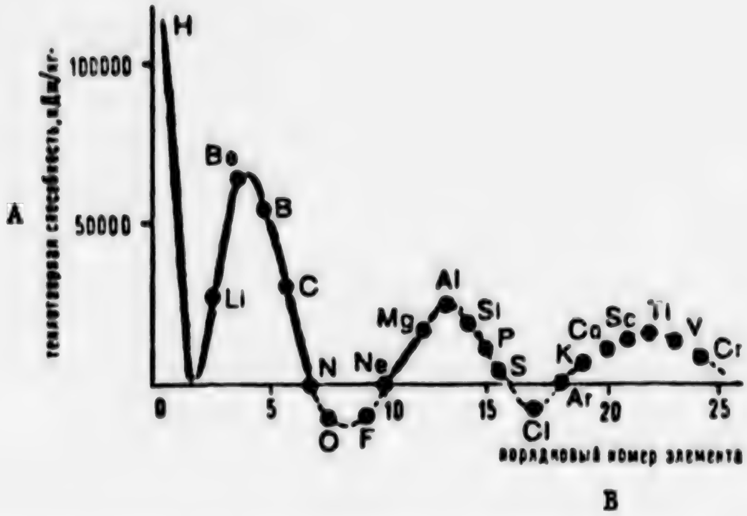

Figure 1. Calorific Power of the Elements Depends on the Number on the Periodic Table.

For oxidizing agents calorific power is shown conventionally in the form of negative values.

Key: A. Calorific power kJ/kg B. Number of element on periodic table.

* * * * *

This does not exhaust the advantages of the metallic fuels in the first two sequences of the periodic table. Chemically they are extremely active and can therefore be used in the combustion not only of free oxygen but also oxygen inside the molecules of other chemical compounds, as for example, water and carbon dioxide. This significantly extends the range of possible oxidizing agents for rocket and jet engines. Yet another not insignificant advantage of a metallic fuel is its high density, which means compactness for fuel reserves. Finally, metallic fuels can be stored for indefinite periods.

After Use, Combustion.

The advantages of metals as fuels for rockets were first evaluated by F.A. Tsander and Yu.V. Kondratyuk. They noted that when aluminum burns 1.6 more heat is given off per mass unit of combustion products that in the combustion of gasoline; when lithium is burned this figure is double.

In an article entitled "Flights to Other Planets" (1924) F.A. Tsander suggested that in a space rocket wings made from Duralumin or Elektron be used during the initial part of the flight (within the Earth's atmosphere). Since the wings will not be required in empty space they can be retracted into the rocket and converted to powder or melted and then burned as fuel. The idea

of using structural elements on an interplanetary vehicle as extra fuel opens up possibilities for increasing the fuel reserves and reducing the passive weight of the rocket. And although the major technical difficulties associated with implementing the idea have not been resolved, it is by no means fantasy.

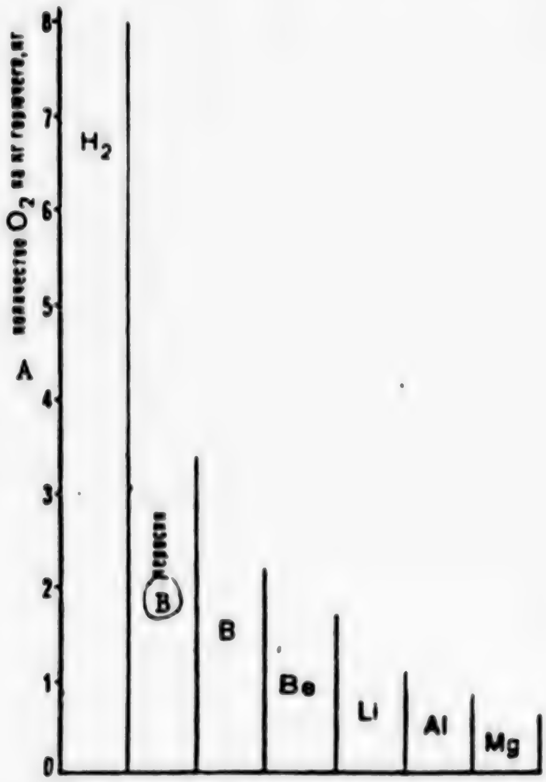

Figure 2. Amount of Oxygen Needed for Complete Combustion of 1 kg of Fuel

Key. A. Amount of O_2 per kg of fuel, kg.

B. Kerosene

Additives.

Solid-fuel rocket engines are simple, easy to operate and highly reliable. They are used in meteorological, aerological and hail-suppression rockets and flares. They are used as the acceleration engine in space rockets. Finally, solid-fuel rockets make up the basis of the rocket arsenals of today's armies.

According to figures from abroad, most of the solid-fuel rockets now known contain metallic additives, most often aluminum. The metal is added to the fuel in the form of a fine powder. The metallic additive makes it possible to significantly increase exhaust velocity and even increase fuel density and combustion stability. For example, the addition of 15 percent aluminum to one of the fuels has increased the temperature of the combustion products from 2,220 K to 3,260 K, while the exhaust velocity of the combustion products has risen from 2,370 to 2,530 meters per second.

When they burn, however, metals form oxides that at the temperature of the working rocket engine remain in liquid or even solid state. Condensed combustion products (in contrast to gaseous products) cannot improve the work of expansion

and markedly lower the efficiency of the conversion taking place in the nozzle: the conversion of the thermal energy of the combustion products into kinetic energy in the exhaust flow. Therefore, it is advisable to increase the content of metallic fuel in a solid-fuel rocket fuel only up to a certain level. If this level is exceeded the exhaust velocity of the combustion products starts to fall.

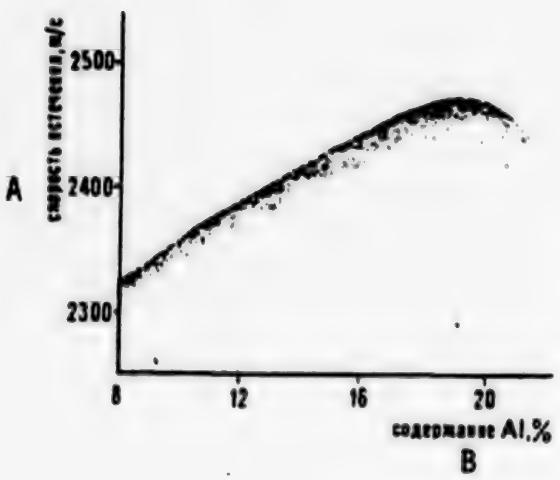

Figure 3.

Dependence of Exhaust Velocity of Combustion Products of Solid Fuel on Content of Metallic Aluminum in the Fuel.

It can be seen from the graph that the addition of 18-20% aluminum is undesirable.

Key. A. Exhaust velocity, m/s
B. Aluminum content, %

In a liquid-fuel rocket engine replacing the liquid fuel with metals (even beryllium or lithium) does not make it possible to exceed the known characteristics of high-energy fuel systems, namely fluorine-hydrogen or oxygen-hydrogen. However, when a triple fuel system such as metal-hydrogen-oxygen or metal-hydrogen-fluorine is used exhaust velocity can be significantly increased. For example, the addition of beryllium to a liquid rocket fuel (fluorine-hydrogen) makes it possible to increase the velocity of the combustion products from 4,100 to 4,560 meters per second.

Metal Burns in Air.

Liquid- and solid-fuel rocket engines operate on a fuel both of whose components (both the fuel and the oxidizing agent) are aboard the rocket. In an air-breathing jet engine atmospheric oxygen is the oxidizing agent. And this makes it possible to considerably reduce the weight of the aircraft.

Of the air-breathing jet engines the simplest to build is the ramjet. During flight air enters the engine via the intake of a diffuser. In the diffuser, thanks to the velocity head the air is compressed, the rate of flow at the intake of the combustion chamber is reduced and pressure increases. Because

of the increased pressure in front of the nozzle and the high temperature of the combustion products significant velocity is achieved for the exhaust gases. In this engine light metals can also be used most efficiently as fuel.

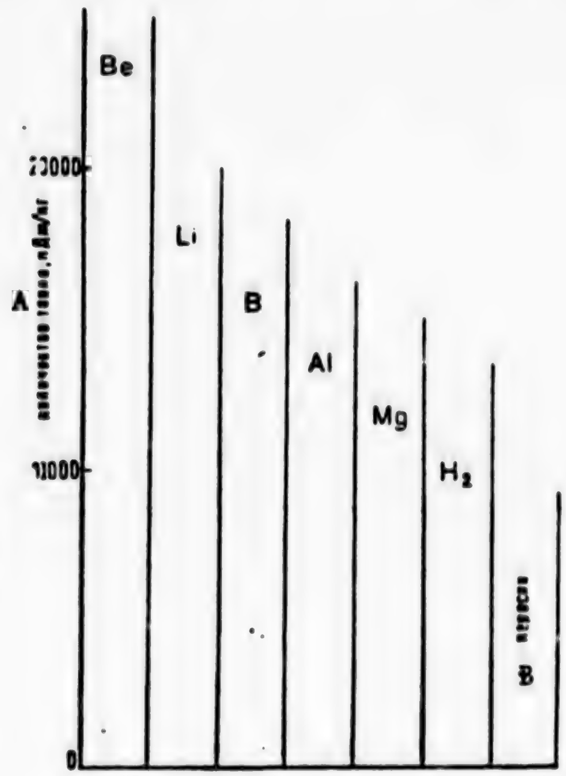

Figure 4. Amount of Heat Given off per Kilogram of Combustion Products (the oxidizing agent is oxygen)

Key. A. Amount of heat, kJ/kg. B. Kerosine

* * * * *

When metals burn in air their main advantage is fully displayed, namely the great amount of heat given off per mass unit of combustion products. On the other hand, condensed particles have less effect on the operation of the engine: in a ramjet they are equally distributed in a great volume of air.

In a liquid fuel metals are added in the form of a suspension or a colloidal solution. To prepare colloidal solutions a very fine metallic powder is required, with particles of the order of 10^{-6} to 10^{-8} millimeters; suspensions are prepared more simply but during storage they layer out and the metal precipitates out. Is is therefore much more convenient to use metals in a solid fuel. Up to 65 percent of a solid fuel can be metallic fuel, while at the same time such compositions contain little solid oxidant. Here the combustion reaction is started in the surface layer of the charge; the gases forming eject particles of the metal from the surface into the air flow, the particles are heated, and the metallic fuel reacts with atmospheric oxygen.

Ramjet engines using solid metallized fuel are extremely simple and reliable: there is no need for pumps, valves or feed lines.

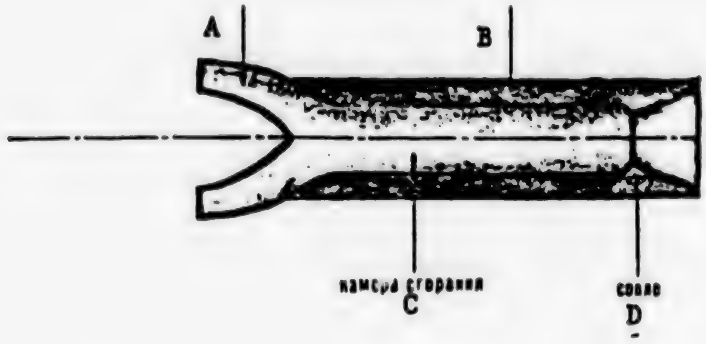

Figure 5. Ramjet Engine.

Its thrust (P) depends on air flow rate (G), flying speed (V) and exhaust velocity of combustion products (U): $P = G(U - V)$

Key. A. Diffuser C. Combustion chamber
B. Fuel D. Nozzle

* * * * *

Metal Burns in Water.

The high chemical activity of the metals in the second and third sequences of the periodic table make it possible to manage without the traditional oxidizing agent--free oxygen. These metals readily remove the oxygen bonded in oxygen-bearing molecules, as for example water:

$$Mg + H_2O \rightarrow MgO + H_2\uparrow$$

$$2Al + 3H_2O \rightarrow Al_2O_3 + 3H_2\uparrow$$

When magnesium is burned in water 8,510 kJ are given off per kilogram of combustion products--1.76 times less than combustion in pure oxygen but 1.3 times more than in air (the corresponding figures for aluminum and lithium are 8,800 kJ and 11,158 kJ respectively).

It it very important that the product of these reactions--hydrogen--is an excellent working medium. And if water enters the combustion chamber in amounts in excess of stoichiometry the excess is converted into superheated steam, which is also not a bad working medium.

This is why the use of fuels based on the light metals that react in water makes it possible to create a highly efficient engine for underwater equipment, developing speeds in excess of 150-170 k.p.h., which cannot be achieved with a propeller.

K.E. Tsiolkovskiy's Idea.

K.E. Tsiolkovskiy proposed the idea of an initial acceleration for a space rocket along the Earth's surface: "Gaining velocity on the Earth has major advantages since by moving along its surface we are able to obtain a constant flow of energy without losing our reserves... The Earth rocket is hurled along rails at the same acceleration as a space rocket. When the greatest velocity is gained and the Earth rocket begins to slow down the space rocket breaks loose from the Earth rocket through the force of inertia and proceeds on its way, gathering speed by firing its own engine. Slowed down by the air or by other means the Earth rocket moves further along the track but increasingly slowly, until it comes to a halt."

Today this idea from our great countryman is attracting increasing attention on the part of researchers and developers of rocket technology. First, given today's scales of space exploration the question of improving the economies is acute. Saving fuel for long-range flights and saving the launch (Earth) stage of a space rocket for repeated use is an extremely urgent problem. Second, various kinds of high-speed ground transportation have already become a reality. It has been suggested that a transportation system based on magnetic or aerodynamic suspension be used for the initial acceleration of a rocket. It is very attractive to accelerate the rocket not on dry land but from a water surface--a floating platform with a gliding bottom, with a hydrofoil or air cushion.

In this event it becomes possible to burn a metallic fuel in the launch stage, using the water outside the vehicle as the oxidizing agent.

It is not difficult to calculate that if the water outside the vehicle is used as the oxidizing agent and aluminum is used as the fuel, the fuel reserve required to initially accelerate a rocket up to the required velocity would be 1.5-2 times less. And the weight of the rocket train would be lighter by a good third.

After acceleration the space rocket separates and flies off, while the Earth rocker, or more accurately the water stage, smoothly decelerates because of water resistance and remains whole and intact.

Engines for Venus.

Some 97 percent of the atmosphere of Venus consists of carbon dioxide, which, as is known, does not support combustion. In a carbon dioxide medium neither hydrogen nor hydrocarbon fuel can burn. However, magnesium, aluminum, lithium, beryllium and boron readily take up the oxygen in this compound:

$$2Al + 3CO_2 \rightarrow Al_2O_3 + 3CO$$

True, the amount of heat given off in this reaction is only half that for combustion in oxygen per kilogram of aluminum (15,048 and 30,932 kJ/kg respectively). We note, however, that oxygen makes up only 23.2 percent of the Earth's atmosphere, while on Venus 97 percent of the atmosphere is carbon

dioxide. If this is taken into account, then under Venusian conditions two-thirds as much heat is given off per kilogram of combustion products from aluminum as compared with terrestrial conditions. Moreover, as a result of combustion, CO--a gas 1.57 times lighter than CO_2--is formed around the liquid or solid particles, and therefore the working medium possesses better work capacity. In general the light metals make ideal fuels for a ramjet operating in the Venusian atmosphere.

Meanwhile, the use of an ordinary rocket engine is totally excluded under Venusian conditions. For efficient operation of a rocket engine it is essential that the inner pressure be 15-20 times greater than the ambient pressure into which the gas from the nozzle is ejected. Since pressure on the surface of Venus is about 100 atmospheres, pressure in the engine would have to be higher than 1,500-2,000 atmospheres.

In the ramjet, however, pressure is only slightly greater than ambient pressure. And at any given flying speed, thrust from a ramjet grows proportionally to the density of the atmosphere in which the vehicle is flying.

Metals are excellent fuels, compact and reliable. And the further we go into space and the deeper into the world's oceans, the greater the need for space and deep-water engines. However, they are needed not only for this. Magnesium, aluminum and lithium burn excellently in air and do not give off toxic exhaust, while their combustion products are oxides that can easily be reconverted into metals.

It can be suggested that not only space vehicles but also automobiles will be powered by these fuels in our century.

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UDC 629.7

PERIODIC OSCILLATIONS OF SATELLITE GYROSTABILIZER RELATIVE TO CENTER OF MASS IN CIRCULAR ORBIT

Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 21, No 6, Nov-Dec 83 (manuscript received 17 May 82) pp 838-850

SAZONOV, V. V.

[Abstract] A system of differential equations for the movement of a satellite gyrostabilizer relative to the center of mass under the effect of gravity in a circular orbit is considered. The gyrostabilizer is a solid body with a symmetric rotor located inside it; the rotor's axis of rotation matches its dynamic axis of symmetry and it is rigidly attached to the lifting body. The system of equations employs two Cartesian coordinate systems, for the lifting body and for the orbital system. It is assumed that inherent kinetic moment is great and so the system contains a large constant. Symmetric solutions for the system are sought for the cases of h equals infinity and $|h|>>1$. Solutions are constructed in the form of formal series for the negative integer indexes of the large constant and are examined numerically. Figures 6; references 8 (Russian).
[78-9642]

AZERBAIJAN INSTITUTE DEVELOPS SUBSATELLITE MEASUREMENT SYSTEMS

Moscow PRAVDA in Russian 27 Mar 84 p 3

[Commentary by T. Ismailov, doctor of technical sciences: "Space Exploration of Earth's Natural Resources"]

[Text] The high accuracy, practicality, large scale, economic effectiveness and great informativeness of exploration of Earth's natural resources from space have been confirmed in practice and will be further improved in conformity with the resolutions of the 26th CPSU Congress. Exploration of Earth from satellite orbits is based on methods involving remote sounding of the atmosphere and the underlying surface. These methods entail measuring from space various characteristics of the electromagnetic radiation field in the visible, infrared and radiofrequency wavelength region, above all, characteristics of solar radiation transformed by the atmosphere and reflected from the surface, and also natural radiation emitted by the systems: dry land-atmosphere, ocean-atmosphere. Whichever methods are used, in practice scientists are preoccupied with the same question, namely, how can the obtained information be used most effectively for scientific purposes and in specific branches of the national economy?

At the present time no simple answer can be given to this question because it requires a combined approach to a wide range of natural history, applied physics and design-production problems. The experience acquired in the USSR and abroad over many years demonstrated convincingly that a common methodical basis is required to ensure success. Organizations of the Academy and of the branches are striving to elaborate such a "common denominator." The latter include the Institute for Space Exploration of Natural Resources--the chief organization of our Association.

While it participates actively in implementing the nationwide program for exploration of Earth from space, the institute is engaged in many research projects related to its applied physics aspects. Interesting and useful results were obtained which have already been applied in practice.

To begin with, I mention the subsatellite automatic data measurement system developed by Soviet scientists and specialists. This equipment is used in aerial and satellite control-measurement areas. The system was designed for reception, preprocessing of data (in a search or operational mode) and the change

from occasional to systematic measurements of various parameters of natural objects according to a given program.

The subsatellite system comprises continental sea and airborne component units which can operate both synchronously with spacecraft, as well as autonomously in an automatic data collection and preprocessing mode with real time merging of data measured over the entire territory of the test area. The modular design of the basic elements of the system allows for an expansion of its capabilities during a change of the research project program. From an engineering design standpoint, the system has no analogue.

Introduction of the subsatellite system on a country-wide scale created realistic preconditions for making great progress in the solution of one of the most important problems in the natural history of the cosmos, namely, automatic decoding of the ever-increasing flow of data transmitted from satellites.

The Academy of Sciences of the Azerbaijan Republic is implementing concrete steps in this direction with the active support of local organizations. In particular, the proposals of scientists for the development of subsatellite systems have already been worked out in their engineering aspects and our design-engineering bureaus have prepared the pertinent engineering documentation. Last year several system configurations were produced for placement on territories of the RSFSR, the Uzbek, Azerbaijan and Moldavian Republics. One of these configurations was used during the 150-day flight of cosmonauts V. Lyakhov and A. Aleksandrov.

During that period an unusual experiment was carried out in the Shcheki-Zakataly measurement area in which representatives from several institutes of the Academy of Sciences participated--space research, radioengineering and electronics, geology and the lithosphere, Institute of Physics of the Byelorussian Academy of Sciences as well as the Scientific Research Institute of Biology of Leningrad State University, the Priroda State Scientific Research Center and other scientific establishments.

Synchronous measurements at five different levels (space station, two aircraft laboratories, one helicopter-laboratory and ground measuring equipment) were carried out for the first time in the Soviet Union. Many perfected instruments were mounted on measurement platforms (multichannel spectrometers, superhigh frequency and infrared radiation meters, etc.). Standard aerial photography equipment and the MKF6 multizonal camera were used extensively in the experiment.

An important fact is that all these instruments were aimed at measuring the same parameters of selected natural objects which had been explored earlier using ground methods.

During the flight of the Salyut-7 space station we carried out measurements in the Caspian Sea area together with the Institutes of Atmospheric Physics and Oceanography of the Academies of Sciences of several republics, the Marine Hydrophysics Institute of the Ukrainian SSR Academy of Sciences, the Moscow Applied Physics Institute and a number of branch organizations. The automatic

marine data measurement system, developed in our Association, installed on the scientific research ship "Bakuvi", the AN-30 airborne aircraft laboratory (also developed in our Association) and the MI-8 helicopter-laboratory, equipped with spectrometry, radiometry and other equipment participated in the experiments. Measurements on a stationary platform mounted at sea were carried out simultaneously.

The main purpose of this experiment was to work out methods for simultaneous measurements of sea objects from various altitudes (synchronously with measurements transmitted from the Salyut-7 space station), to test, under real conditions, the methods which have been elaborated by us to carry out such measurements, and to verify the proper functioning and reliability of equipment. Besides these objective, oceanographers may be interested in data on the dynamics of surface waters in a bounded sea area.

At the same time cosmonauts learned to distinguish with a high degree of accuracy various shades of color of sea water: spots of various colors were produced artificially on the surface of the sea, their color was ascertained, after which specialists played a guessing game with the cosmonauts. This was carried out concurrently with instrument and visual observations at sea, at two levels, from a helicopter or airplane, with simultaneous recording and storage of measured characteristics. The experiment will contribute to the advancement of satellite physical hydrology.

Our methods and technology are being used on an increasing scale to further the interests of the economy of our republic. Research whose purpose is to improve methods for evaluating and taking stock of plant-vegetation resources in Azerbaijan, conducted jointly with physical geography specialists, is a characteristic example. In the 1982-1983 period this research was carried out over the territories of several rayons and it covered an area in excess of 400,000 hectares.

Specifically, collation maps of the productivity of forage lands based on aerial and satellite photography materials were drawn for the first time. The productivity of the summer and winter pastures was evaluated qualitatively and quantitatively for the first time, which will be helpful in working out measures for the rational use of the forage resources of our republic.

Another example is the satellite photography tectonics maps of the Greater Caucasus, which was elaborated for the first time in our country jointly with the Institute of Geology of the Azerbaijan SSR Academy of Sciences and the Union Scientific Research Institute of Geophysics of the USSR Ministry of Geology. Geological prospecting can be made more effective with the aid of this map. Besides, the obtained results are also valuable to the entire scientific community.

For example, they can be used by our colleagues in fraternal socialist countries with whom we fruitfully collaborate as members of the working group for remote sounding of Earth through the Intercosmos organization. We exchange our experience with them and we assist them with aerial and satellite photography work on the territories of these countries. In the last few years an

experimental prototype of the subsatellite system as well as individual component units of the system and instruments were used to explore areas in Bulgaria, Hungary, Vietnam, Cuba, Mongolia and Czechoslovakia.

At the present time a new space expedition is exploring our planet. L. Kizim, V. Solov'yev and O. At'kov are conducting extensive research related to exploration of Earth's natural resources, which will further promote the use of cosmonautics for the purpose of meeting the needs of the economy of our motherland and other countries of the socialist commonwealth.

12583
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'DUBNA-INTERCOSMOS' SPACE COMMUNICATIONS TEST FACILITY

Moscow PRAVDA in Russian 7 May 84 p 4

[Article by L. Chausov]

[Abstract] The article reports on the work of a space communications test facility of the socialist countries' "Intercosmos" organization. Called the "Dubna-Intercosmos" international experimental sector, it is the center of a system for testing new frequency bands for space communications. In addition to the center in Dubna, the system includes facilities in Bulgaria, Hungary, East Germany, Poland and Czechoslovakia.

The purpose of the system is to amass scientific data necessary for the development of satellite communications networks. Doctor of Technical Sciences V. Bykov, director of the experimental sector, explained that the opening up of new, more convenient frequency bands helps to improve the quality of signals and to increase television, telephone and other communications traffic via satellites. It is mentioned that one of the satellites being utilized in the system's tests is the "Luch-1", which is in geostationary orbit above the Atlantic Ocean. Among the experiments being conducted with the system are ones aimed at learning how to prevent signal attenuation due to rain, snow, fog and other atmospheric phenomena, and ones involving transmission of digital television signals, which saves communications channels.

It is noted that the main computer of the facility at Dubna is backed up by a computer at a facility in Neuholm, East Germany. With a satellite hookup, the two computers exchange information every 10 seconds via a telephone channel. If a sudden malfunction of the Dubna computer occurs, the Neuholm computer continues to receive and store data.

FTD/SNAP

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'INMARSAT' STATION IN ODESSA

Moscow IZVESTIYA in Russian 18 Apr 84 p 3

[Article by A. Knop (Odessa)]

[Abstract] The article provides information on the equipment and activities of the USSR's first international marine satellite communications station, which went into operation recently.

The station is located 30 kilometers from Odessa, on the Khadzhibey estuary. It is operating within the framework of the International Marine Satellite Communications Organization "INMARSAT", one of whose main tasks is the support of safe navigation. It is noted that "INMARSAT" may also be used in support of the international "COSPAS-SARSAT" program for locating ships and airplanes in distress.

The Odessa station and a similar station which is under construction in Nakhodka are designed for communications with two oceans simultaneously. The Pacific and Indian oceans will be served by the Nakhodka station. The Odessa station is equipped with two parabolic antennas, one of which is directed toward the Atlantic Ocean and the other toward the Indian Ocean. An account is given of radiotelephone communications which personnel of the Odessa station conducted with ships in these oceans. Messages were transmitted via the satellites "Intelsat-V" and "Marex-A", which were over the Indian and Atlantic oceans, respectively.

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IMPROVEMENT OF 'COSPAS-SARSAT' SYSTEM CAPABILITIES

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 6 May 84 p 4

[Article by A. Valentinov, science commentator]

[Abstract] The lengthy article records conversations with specialists regarding the operation and results to date of the international COSPAS-SARSAT satellite-aided system for locating ships and airplanes in distress.

Yuriy Sergeyevich Atserov, chairman of the All-Union Marine Satellite Communications (Morsvyaz'sputnik Association, traced the history of this system and identified the satellites and types of ground equipment it is using. A. V. Belousov, head of the Ministry of the Merchant Fleet's COSPAS System Center, which is located on Zhdanov Street in Moscow, commented on the advantages of new emergency radio buoys which are being introduced into the system in line with a Soviet proposal. These buoys operate on a frequency of 406 megahertz. As a result of this innovation, a satellite does not have to be simultaneously in the audibility zone of the buoy and of a ground satellite-information receiving post (PPI) in order to relay signals from the buoy, Belousov explained. Soviet satellites have a memory for the 406 MHz frequency which stores the signals until the satellite enters a PPI audibility zone. The satellite transmits the information to the ground within 10 to 15 minutes after its reception. At this frequency, the satellite's equipment also is able to determine the buoy's coordinates from the signals and furnish ready data to the PPI. The Moscow center is now receiving data from PPI located in Moscow, Arkhangel'sk and Vladivostok, and a fourth post is to go into service in Siberia.

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SEISMIC PRECURSORS IN THE IONOSPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 10, Oct 83, pp 17-21

[Article by M. B. Gokhberg, V. A. Pilipenko and O. A. Pokhotelov]

[Abstract] Ruptures in the terrestrial crust leading to earthquakes are accompanied by current flows over tens to hundreds of kilometers and produce fields which trigger plasma oscillations in the ionosphere resulting in anomalous radio waves and variations in ionosphere layer critical frequencies which can serve as quake precursors. Space vehicle instrumentation was used to study electromagnetic anomalies and ionosphere parameters near quake epicenters. Data from the OGO-6 satellite showed conversion of ion cyclotron plasma oscillations into whistlers with frequencies of approx. 200 Hz. Data from the AE-C satellite showed a plasma concentration fall at the epicenter of up to 20% and, in general, only plasma concentration drops were observed. Similar results were obtained on the ISIS-2 satellite. The processes observed over epicenters appear to be due to upward drift components in plasma in intersecting electric and magnetic fields, and small altitude variations generate significant plasma characteristic changes. Possible plasma heating by acoustic range waves forerunning shocks was excluded because necessary amplitudes would already have been detected.

12497
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LAUNCH TABLE

LIST OF RECENT SOVIET SPACE LAUNCHES

Moscow TASS in English or Russian various dates

[Summary]

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
3 Apr 84	Soyuz T-11	(Cosmonauts Malyshev, Strekalov and Sharma; docked with "Salyut-7"--"Soyuz T-10" on 4 April)			
4 Apr 84	Cosmos-1547	39,340 km	615 km	11 hrs 49 min	62.8°
10 Apr 84	Cosmos-1548	359 km	177 km	89.5 min	67.1°
15 Apr 84	Progress-20	277 km	192 km	88.9 min	51.6°
		(Automatic cargo ship launched to "Salyut-7")			
19 Apr 84	Cosmos-1549	394 km	208 km	90.2 min	72.9°
22 Apr 84	Gorizont	36,320 km	--	24 hrs 23 min	11.4°
		(Communications and TV satellite; near-stationary circular orbit)			
8 May 84	Progress-21	264 km	193 km	88.7 min	51.6°
		(Automatic cargo ship launched to "Salyut-7")			
11 May 84	Cosmos-1550	1,025 km	993 km	105 min	83°
11 May 84	Cosmos-1551	305 km	209 km	89.3 min	72.9°
14 May 84	Cosmos-1552	344 km	191 km	89.6 min	64.9°
17 May 84	Cosmos-1553	1,020 km	977 km	104.8 min	82.9°

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
19 May 84	Cosmos-1554.-1555,-1556	19,125 km	--	11 hrs 16 min	64.8°
		(3 satellites launched by single booster; to test elements and equipment for a space navigation system to determine location of civil aircraft and merchant and fishing vessels; circular orbit)			
22 May 84	Cosmos-1557	276 km	221 km	89.2 min	82.3°
		(Incoming data transmitted to State Scientific Research and Production Center "Priroda" for processing and use)			
25 May 84	Cosmos-1558	318 km	178 km	89.1 min	67.2°
28 May 84	Progress-22	(Automatic cargo ship launched to "Salyut-7")			
29 May 84	Cosmos-1559--Cosmos-1566	1,512 km	1,444 km	115 min	74°
		(8 satellites launched by single booster)			
30 May 84	Cosmos-1567	462 km	428 km	93.3 min	65°

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